SCIENTIFIC AMERICAN
No. SUPPLEMENT. 364

Scientific American Supplement, Vol. XIV., No. 364. Scientific American. established 1845. | NEW YORK, DECEMBER 23, 1882. | Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

A FRENCH STEAM FIRE ENGINE.

THE accompanying figures represent a type of steam fire engine manufactured by Messrs. Flaud & Cohendet, of Paris. The apparatus, which is designed to be drawn by two horses, is provided with a seat for the driver and for several firemen, and underneath this are located the tool-box, nozzles, and the hose with its couplings. The suction pipes are placed to the right and left under the footboards. The frame that carries the entire mechanism is U-shaped, made of iron, and fixed directly to the boiler. The latter, which is tubular and on the Field system, is placed behind the pump, and is closed at its lower part by tubes only, to the number of 493, which, being directly exposed to the fire, allow steam to be got up very quickly, say in from eight to ten minutes with cold water. The fire-place consists of a conical box widened at the base, so as to increase the surface of the grate. The steam-port is provided at its orifice inside the boiler with a sort of cap containing apertures for the passage of the steam. This cap is designed to prevent the carrying over of water that would have necessarily occurred through the great rapidity with which the steam is generated. The boiler, which is tested up to 10 atmospheres, is provided with two pressure-gauges, one on the engineman's side of the apparatus and the other on the stoker's. It is likewise provided with a safety-valve, water-level, gauge-cocks, and a discharge valve that permits of letting off steam in case of a sudden stoppage of the engine. At the base of the boiler there is a platform for the stoker, who stands thereon and grasps the copper handle, B, while the engine is proceeding to a fire. On each side of the platform there is a box to hold fuel. The boiler may be fed in three different ways: (1) by an injector placed on the side of

FRENCH STEAM FIRE ENGINE.

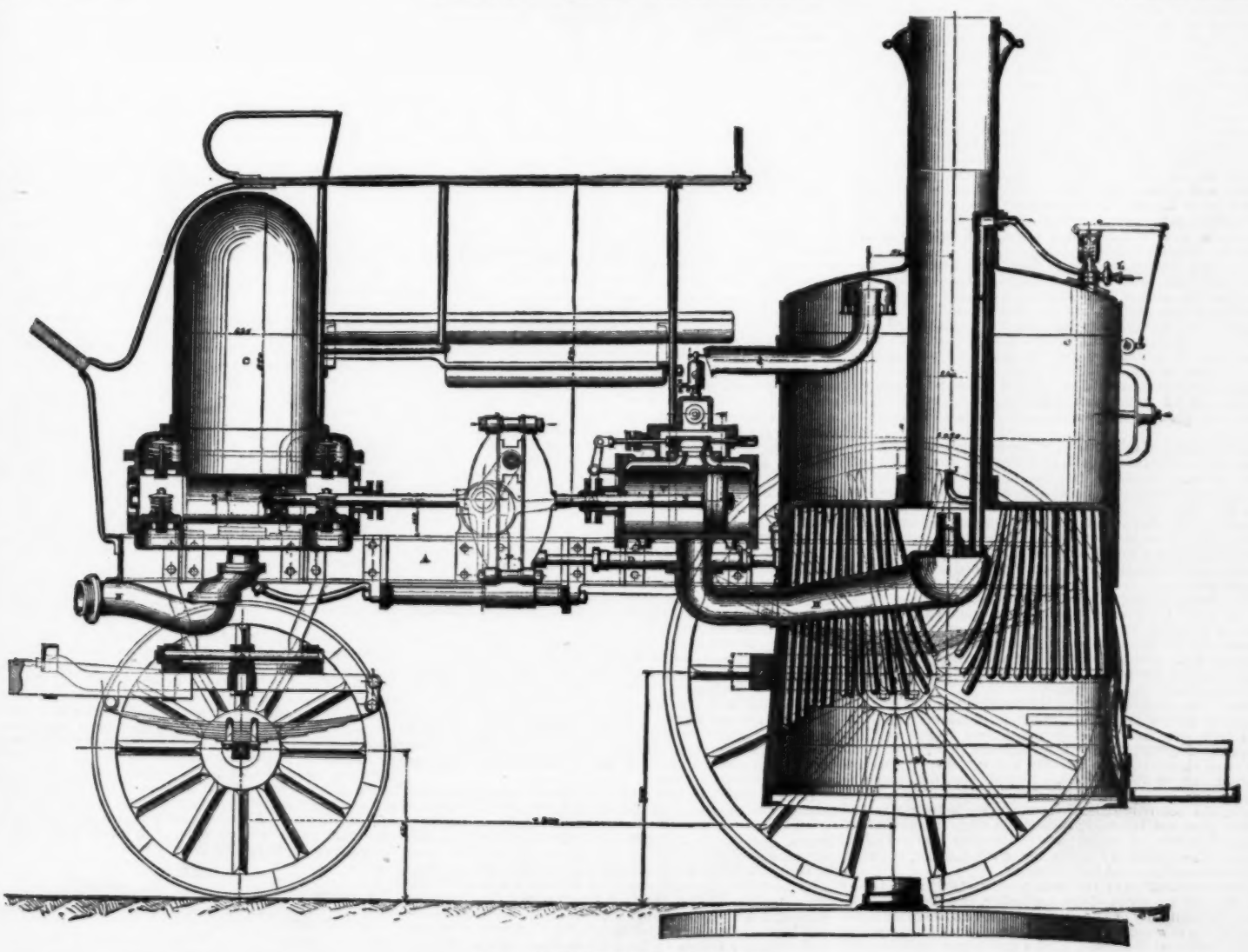


FIG. 2.—LONGITUDINAL SECTION.

IMPROVED FRENCH STEAM FIRE ENGINE.—FLAUD & COHENDET, BUILDERS, PARIS.

the boiler; (2) by a feed-pump actuated by the engine itself; or (3) by a pipe which puts the air-chamber of the pumps in communication with the boiler, and thus permits of water being introduced directly into the latter while the apparatus is running. The mechanism, properly so called, consists of three steam-cylinders, V, and three pump-chambers, E, fixed to the iron frame. The steam from the boiler, in order to reach the cylinder, passes through a cast-iron box, F, in which there is an introduction slide-valve maneuvered by a hand-wheel, G. The pistons of the pumps are connected with those of the steam-cylinders. The pistons of the latter are 0·19 of a meter in diameter, have 0·29 of a meter stroke, and actuate, through a triple crank and slides, a shaft which carries three distributing eccentrics that set in motion the cylinder slide-valves through the intermedium of an oscillating lever working on a fixed point. The exhaust-steam, passing through a pipe, H, makes its exit through the smoke-stack, and thus serves to create a draught in the fireplace. To hasten the operation of getting up steam, the apparatus is provided with a blower, J, through which escapes a jet of steam when the cock, L, is opened.

The three pump-chambers are double acting, each having two suctions and two force valves. The cylinders are, 0·135 of a meter in diameter, and each discharges about one cubic meter of water per minute. Suction is effected through two necks, M, places each side of the engine. These are 0·125 of a meter in internal diameter, and each is surmounted by an air-chamber, M', and connected by a pipe with the hydrant.

To the two pipes, N, which have an internal diameter of 85 millimeters, is attached the hose. One valve in common permits of closing one or the other of these induction pipes, without the two ever being closed together. Above the three pump-chambers is placed a large air-chamber, C, provided with a pressure-gauge.

The subjoined table shows the results obtained in three successive experiments, corresponding to nozzles of 35, 40, and 45 millimeters diameter:

	Orifices of nozzle.		
	35 mm.	40 mm.	45 mm.
Boiler pressure	8 k.	8·5 k.	8·5 k.
Pressure in air-chamber	8 k.	7·5 k.	7·25 k.
Length of stream	68 m.	78 m.	70 m.
Number of revolutions per minute	92	110	123
Discharge in liters per minute	2·282	2 736	3 060

PROGRESS OF MECHANICAL ENGINEERING.*

By ROBERT H. THURSTON, A.M., C.E., President.

MATERIALS.

IN the handling of metal, we have still much to learn. The weakness of the large sections of metal necessarily used in our heavier work still remains a serious evil, and our inability, especially when using steel, to secure the highest tenacity of the metal is a standing reproach to our profession. I have had occasion to test hundreds, yes, thousands, of samples of iron and steel during the last few years, and have never yet found a maker able to give equal tenacity in large and small sizes. This difficulty seems particularly serious in dealing with forged iron built up of scrap, and with heavy sections of any kind of steel. I find iron carrying 75,000 pounds per square inch in No. 8 wire, 55,000 in inch bars, and falling to 40,000, or even 35,000, in heavy engine-shafts and beam-straps. Steel varies still more seriously. It is to be hoped that, with the more general use of ingot metal, the introduction of hydraulic forging, and of improved methods of heating and handling, so as to avoid the introduction of many small parts in building up large masses, or frequent exposure to high temperatures in the process, this element of cost and danger may, in a measure at least, disappear.

The great testing machine at Watertown Arsenal is constantly at work, under the direction of Colonel Laidley, sometimes for private and sometimes for public benefit, and has already done some extremely valuable work in that important and unexplored field, the investigation of the strength of large sections and parts of structures. Its most valuable work is done intermittently, and its usefulness is far less than it should be and would have been had its original purpose been adhered to. There seems no immediate prospect of the resumption of the great work organized in 1875, and planned and commenced by the Government Board.

The petitions of this society, of the Society of Civil Engineers, of the Institute of Mining Engineers, of the Iron and Steel Association, of the faculties of the leading technical schools and colleges of the United States, and of business men and other private individuals of all classes, with all the influence that they could command, separately or collectively, have been inadequate to secure the restoration of that Board, or the creation of a similar organization, or the resumption of the great work barely planned and begun by the old Board.

This fact is as suggestive of the necessity of a movement on the part of the business men of the country for the purpose of securing some influence in its government as it is remarkable as illustrating their utter impotence to-day. Meantime, the Ordnance Bureau of the Army has a small appropriation for use in this direction, and we shall look with hopeful interest for results.

But "Iron, tough and true, the weapon, the tool, and the engine of all civilization," as Theodore Winthrop calls it, is now fairly displaced by its younger rival, "*mild steel*," or more exactly, "ingot" or "homogeneous" iron.

For all shapes that can be rolled this revolution is accomplished, and, in forged work of small size, the change is hardly less complete. This is especially true of railroad work, and not only rails, tires, and axles, bolts, rivets, and boiler plate are becoming common in steel, but piston and connecting rods, all forged parts of the valve gear and minor parts of the engine, are now made in this tougher, stronger, and more uniform and reliable metal.

The introduction of the basic process—tardy as it is—by cheapening the stock of the steelmaker, and the steadily increased familiarity of makers and users with the characteristics of the new metal and with the requisites for successful manufacture of demanded grades and better qualities, will undoubtedly, before many years, make its use so general that puddled and forged iron will become almost or quite unknown in our art. The growth of pneumatic steel manufacture in this country during the past ten years has been most remarkable. In 1870 we were making somewhere about 20,000 tons, in 1873 about 160,000 tons, and to-day are turning out one million and three quarter tons; while the price has fallen below that of the finer brands of iron.

A few years ago—even those among us whose hair has hardly begun to gray can remember the time—no engineer, except Telford with his proposed cast-iron bridge of 600 feet span, dared present plans of iron truss or arched bridges of 300 feet span; and Roebling was the only engineer bold enough to attempt much greater spans, even with suspension bridges.

To-day, with improved material and the better knowledge of their quality that comes of intelligent inspection and systematic test, we think little of trusses of 500 feet span or suspension bridges of 1,000 feet and more; and it is even proposed to bridge the Forth at its expansion into the Frith with a steel truss bridge a mile long, containing two main spans of 1,700 feet each. Not the least remarkable and—to those who pay taxes in New York or Brooklyn to defray the cost of the "East River" bridge—interesting fact in connection with this scheme is that it is expected to cost but about $7,500,000. Who shall say that we are not making progress in this direction at least?

The reduction in cost of the purer, stronger, tougher, and more homogeneous grades of so-called "steel" which are to take the place of iron in the near future, and of those which are made by the "open hearth process" especially, will depend principally upon the introduction of the regenerative type of furnace, the great invention of that greatest of metallurgical engineers, our colleague Siemens, and of the lesser inventors who have followed his lead. With this furnace supplying a means of attaining any desired temperature with a pure mild flame and at a wonderfully low cost of production, we are able to produce the boiler steels and similar metals with an economy that permits competition in this field with even the product of the Bessemer process. With the closed furnace, the attainable temperature is only limited by the temperature of fusion of the materials of the furnace. Could a new and sufficiently refractory furnace material be found, it might possibly be able to compete with the electric furnace of Siemens, or with the electric arc with which our colleague Farmer, that Nestor among our electricians, claims long ago to have produced the diamond. The melting of platinum in considerable quantities by Ricketts is now a familiar fact, and is an earnest of what may be expected in the more ordinary departments of metallurgy when such enormous temperatures shall be found manageable.

We are not yet absolutely free from annoyance by the presence of air-cells and minor defects in these "ingot irons" as they are properly called; although such defects have ceased to be dangerous or in any way very serious. Capt. Jones' method of compressing the solidifying ingot by steam pressure, and other devices in imitation of his, are giving us a very homogeneous metal.

Singularly enough, our people, enterprising as we are accustomed to consider ourselves, have not yet made use of the Whitworth system of compression of steel, notwithstanding the fact that its value has been known so many years, and through the wonderful strength, uniformity, and toughness conferred by it have made "Whitworth compressed steel" famous throughout the world. Abroad, its use is extending, and guns, screw shafts, and other heavy "uses" are often made of it. The venerable inventor informs me that he is preparing plans that will enable even large castings of peculiar shapes, as screw propellers, to be made of this material. Some dozen years ago, studying this method and its results, partly for my own satisfaction and partly to obtain material for a report to the Navy Department, I was greatly impressed with its efficiency as even then developed, and its work has since been wonderfully extended and its value correspondingly increased.

Our systems of inspection and test of materials, of parts, and of structures are steadily assuming satisfactory shape, and are becoming very generally, almost universally, adopted in all important work, whether public or private, and it will soon be the exception rather than the rule that supplies, material, or constructions of whatever kind are purchased without a careful determination of their fitness for their intended purpose.

METHODS.

In my last address, I referred very briefly to the modern *method of manufacturing machinery* in quantity for the market as distinguished from the old system, or lack of system, of making machines. This method compels the adaptation of special tools to the making of special parts of the machines and the appropriation of a certain portion of the establishment to the production of each of these pieces, while the assembling of the parts to make the complete machine takes place in a place set apart for that purpose. But this plan makes it necessary that every individual piece of any one kind shall fit every individual piece of another kind without expenditure of time and labor in adapting each to the other.

This requirement, in turn, makes it necessary that every piece, and every face and angle, and every hole and every pin in every piece, shall be made precisely of this standard size, without comparison with the part with which it is to be paired, and this last condition compels the construction of gauges giving the exact size to which the workman or the machine must bring each dimension.

Finally, in order that this same system, which has introduced such wonderful economy into the gun manufacture, into sewing machine construction, and into so many other branches of mechanical business, may become more general, and in order to secure that very important result, a universal standard for gauges and for general measurement, we need an acknowledged standard for our whole country, one that shall be an exact representation of the legal standard measure, and one which shall be known and acknowledged as such, and as exactly such.

It could hardly be expected that private enterprise would assume the expense and take the risk involved in this last work. Such work has heretofore only been done by governments. Yet among our colleagues are found the men who have had the intelligence, the courage, and the determination to accept such risks and to meet such expense, and the men who have the knowledge and the skill needed in doing this great work. I think that the report of our committee on gauges, and the paper of our colleague, Mr. Bond, will show that this great task has been accomplished, and we shall find that we are indebted to the Pratt & Whitney Co., to Prof. Rogers, and to Mr. Bond, for a system of measurement and a foundation system of gauges that will supply our tool makers and other builders with a thoroughly satisfactory basis for exact measurement and for accurate gauging.

It is encouraging to observe that this subject is attracting the attention of men of science, and that so distinguished a body as the British Association for Advancement of Science is taking action regarding it.

DESIGN.

Design is to-day conducted systematically and with scientific adaptation of means to ends. The day of the *soi disant* inventor by profession has gone by, and the educated and trained designer has usurped his place. Reuleaux's kinematic synthesis determines the form to be taken by the machine when once the object sought in its construction is plainly defined, and an intelligent application of the laws and data of strength of materials gives its parts their safest and most economical forms and proportions.

The process of invention thus becomes a scientific one, and the inventor himself, instead of blindly groping for or guessing at results, is seen intelligently creating new and useful forms, and is now entitled to claim the higher credit and the nobler distinction that we gladly accord to him who performs so high an order of intellectual work, and to none more cheerfully than to him who applies the grand science of engineering to production of new forms of mechanism.

As in the fine arts the great painter is known by his success in composition and in form rather than in color, so in our own art the best work is that which is distinguished by excellence of general design, of arrangement of detail and of proportion, while aimless ornamentation has no place. This characteristic of true art will become more fully illustrated as the scientific method of invention and design gains ground. The most direct and simple adaptation of means to end will always be the object sought by the engineer, and the labors of one of our honorary members, Dr. Reuleaux, have led to the development of a scientific method of discovering those means.

HYDRAULICS.

Let us now look in another direction.

The mechanical engineer has open to him as his exclusive province one department which is as yet only partially developed in practice, although well advanced in theory. I refer to that of *hydro-mechanics*, and especially the utilization of water power. Although one of the earliest opened by the old Greek engineers, it has been one of the latest developed. Archimedes, Ctesibus, and Hero were familiar with the principles of fluid pressure; Torricelli, Pascal, Newton, and Bernouilli developed the fundamental principles of hydro-dynamics; Du Buat, D'Aubuisson, Prony, Eytelwein, and, above all others, Darcy, supplied experimental data, but it has been reserved for our own generation to apply the knowledge so early acquired to the production of efficient hydraulic engines.

But a few years ago, the vertical water-wheel, as constructed by Fairbairn for moderate and for high falls, and the undershot wheel of Poncelet were the standard wheels in all countries, notwithstanding their cumbrous size, their slow movement, and the great cost involved both in their own construction and in that of their machinery of transmission. Their efficiency was thought high, although rarely exceeding 75 per cent. These wheels have had their day, and nothing is likely to occur to save the whole class from ultimate disuse.

The turbine, introduced in an effective form by Fourneyron a half century ago, and especially in the late forms of Fontaine, Henccel, Jonval, Schiele, and others abroad, and by Boyden and his successors in the United States, has become the only water-motor in general use. This small, cheap, quick-running wheel has completely displaced all the older forms, whether overshot, undershot, or breast wheels.

The three principal types—parallel, inward flow, and outward flow—are all in use and doing good work.

In Europe, they are all made by good builders, as here; but the tendency seems to be, in the United States at least, to introduce most generally another and peculiarly American type, the inward and downward flow wheel, as illustrated in the wheel built by our fellow member, Risdon.

In efficiency, notwithstanding the comparative neglect of these motors by scientific investigators, there has been a steady and important gain during late years. The improvements which have been *felt out* by makers, working often in the dark—for few builders claim to understand the principles of their art, and no two, even, ever agree in their statements of the principles underlying their practice—have resulted in a gradual elevation of standard, until to-day a wheel which, under favorable circumstances, cannot exhibit an efficiency of 80 per cent. must drop into the background. I have been asked to certify a trial giving, as claimed, 95 per cent.; but that figure could, I am sure, only be attained by chance, if at all, when all conditions conspired in its favor. But wheels are, I have no doubt, doing work by the day and by the week at 80 per cent. It may be said that Boyden did as well a generation ago. True, but only with large wheels, built as carefully as the chronometer is made, and fitted with polished buckets and diffusers, and tested under conditions purposely made the best possible. To-day our builders of turbines give their wheels such exact proportions, and take such care in the ordinary work of the foundry, that they obtain these high figures from wheels almost direct from the sand.

So far has this change gone that our theory of the turbine as modified by friction requires careful revision. Accepting the older coefficients for friction and losses of energy, it will probably sometimes be made to appear, from experimental trials, that the wheels of our best makers are a trifle better than perfect. It would seem from figures sent me that friction, in a well-formed wheel, becomes partly a means of transfer of energy from water to wheel, and that the loss of efficiency due to that element is much less than has been supposed. In some of the later wheels, losses of energy due to eddies occurring within the flowing mass have been reduced to such an extent as to considerably improve their performance. In the regulation of the turbine, an excellence has been attained that is thoroughly satisfactory in some cases, and the best wheels have been found to give an efficiency at half and at three-quarters gate, nearly equal to the best at full gate. As the efficiency at part gate is often more important than at full gate, it is easily seen that this means a vitally important gain.

MILLING.

A feature of recent progress of general interest, not only to engineers, but to every citizen, is the recent change in *methods of milling*.

It has been found that the cutting action of the millstone is not best adapted to the preparation of a good flour; but that the crushing action of the mortar and pestle, or of rolls, is much more efficient. "Roller mills" have been long in use in Europe, and the Hungarian flour, so long noted as the finest in the world, owes its excellence, not simply to the

* From the President's address, delivered before the American Society of Mechanical Engineers at the Annual Meeting, November 2, 1882.

gluten-charged wheat from which it is made, but largely to the systems of "high milling" and of cylinder-milling, by which its fine grades are produced. The system of "high milling" is a process of gradual crushing and grinding by a succession of operations, each of which gives a finer product than the preceding, while the intervals between them permit the grain to lose the slight heat produced by the slow-running stone. The first step removes the silica coating, and the grain is next cracked, then broken up, and finally reduced to fine flour, without loss of gluten or other injury, and with less waste than by the familiar system of "low-milling."

By the latest and best method, the grain is gradually reduced to fine flour by passing through a succession of pairs of rolls. In the great "*Walzen-Mühle*" at Pesth, from eighteen to twenty-four pairs are used in making the fine grades of flour. It is this method that is coming into use in our own country, and our hard Northwestern wheats are made by it into a fine, nutritious flour, rich in gluten, with its grain-cells intact, readily converted into the finest of bread, and making 150 to 170 pounds of loaf per 100 pounds of flour. The great "Roller-mill" at St. Paul, Minn., has a capacity of production of 500 barrels per day, and the hard wheat of the Northwest supplies it with unexcelled grain.

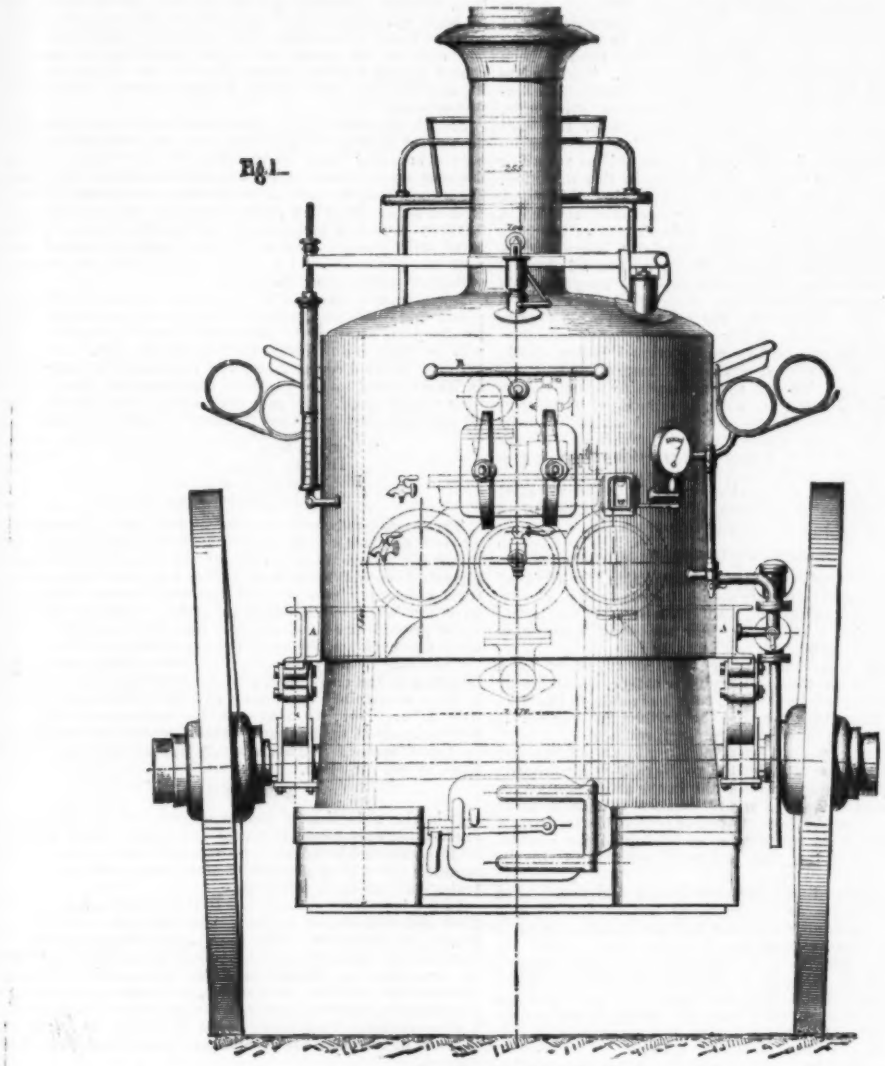


FIG. 1.—REAR VIEW.

IMPROVED FRENCH STEAM FIRE ENGINE.

TRANSPORTATION.

The modern system of collecting the grain raised in all parts of our country, from the Atlantic to the Pacific, from the Southern States to the great grain raising districts of Dakota and Manitoba; the system of storage of the annual product, which now includes 1,600,000,000 bushels of Indian corn and nearly 700,000,000 bushels of wheat, in the great elevators of Chicago, Buffalo, New York, and Boston; these later methods of milling; our organization of a meat supply, taking herds of cattle from Texas for the markets of the North and East and for transportation to Europe; our system of packing meats at St. Louis, Cincinnati, and Chicago, its carriage in refrigerator cars to the seaboard and in marine refrigerators to European ports; our methods of canning meats as well as vegetables, and thus preserving them from season to season; all these now familiar ways of reducing the cost of living are making further advancement toward a higher civilization easier and more rapid. They supply the first of the two essentials to healthful progress—cheap food and other necessarily consumed necessaries of life—and industrious habits of skilled labor are then to be relied upon in the production of the permanent forms of wealth.

Our systems of transportation are peculiarly the work of the engineer, and are the especial objects of his care. Planned by great engineers like John Stevens, John B. Jervis, and others, of whom we boast as statesmen as well as engineers; built under the direction of Roberts, Welch, McAlpine, and other great constructors, they remain in the hands of successors skilled in management and maintenance. All the enormous accumulation of capital in the form of rolling stock is the product of mechanical engineering, and the thousands of trains daily speeding across the land, each representing in value $30,000 to $150,000 and carrying hundreds of human beings or property worth from $20,000 to a half million of dollars, depend for their safety upon the thoroughness of the builders' work, and upon the coolness, skill, and judgment of the man who handles throttle, brake, and reversing lever—an obvious and forcible reminder of the importance of a profession, one of the humblest and least considered members of which is laden with such enormous responsibility.

ELECTRICITY.

Turning now to the work of the last established branch of our profession, *electrical engineering*, we find ourselves still in the midst of a revolution, the progress of which we are all watching with unusual interest—the displacement of our older methods of supplying light and power by a new system, which but lately was but the toy of science, and which comes out of the least utilitarian of all the branches of pure physics. Brush has set up his blazing, sun-like arc lights in nearly every large city in the world; Edison has spread a network of conductors throughout the most densely settled part of New York City, distributing many thousands of his clear mellow lights to send their soft white rays into corners never yet revealed by the feebler yellow light which they displace. It remains to be learned what is to be the cost of the new method of illumination; no figures that I consider wholly reliable have yet been given. It seems sufficiently certain, however, that the arc light is much more economical than gas—the same quantity of light being demanded—for the illumination of streets, public squares, and large interiors, while interior illumination by the incandescent lamps is still considerably more costly than any other usual method.

The dangers to life and property which come in with the new light are becoming rapidly less, as safe methods of laying and connecting the "mains," of handling the plant, and especially more careful and skillful inspection become generally known and practiced. They still remain so great as somewhat to retard the introduction of the electric light.

The secondary batteries of Faure, Planté, and others are likely to aid, after a time, in bringing the light into use in many localities in which it would otherwise be impossible to adopt it with satisfactory results, and in cheapening the cost of supply. They are still too cumbersome to be of as great value for general purposes as was hoped when they were first invented.

Despite every difficulty and every objection, however, the electric light is steadily and surely coming into a very wide field of application. Its beautiful whiteness, its brilliancy and clearness, its richness in the actinic rays, and therefore its power of revealing every shade of every color and of producing the chemical changes of photography, its freedom from heat, from vapor, and from gaseous poisonous products of combustion, and even its curiously interesting effect in promoting the growth of plants, must all prove qualities of such importance that its extensive introduction, although hardly its exclusive use, must be soon accomplished. As remarked recently by Siemens, gas will long remain the poor man's friend, supplying his rooms with light, and probably his kitchen, ere long, with heat.

Little has yet been done in the electrical transmission of power, except to determine experimentally the efficiency of the system.

I stated last year that the efficiency of the Edison system had been determined, and found to be about 90 per cent. Howell's results have been confirmed by Hopkinson, and by Siemens abroad, and are also checked by reference to Tresca's earlier work. Recently the Messrs. Gibbs have made an extended study and test of the Western machine; and they also find the earlier reported figures for electrical transmission more than confirmed. Taking the probable efficiency of the two machines forming the system in electrical transmission at 85 per cent. each, we obtain a net efficiency of the system, exclusive of conductor, of above 70 per cent.—this is precisely Tresca's figure, if I remember aright—and, allowing liberally for losses on the line, we may say that 60 per cent. of the power generated may be utilized. But a good engine of large size should give a horse-power with 2 to 2½ pounds of coal per hour, while the small engines which may be displaced by it will demand from 8 to 12 pounds, thus giving an enormous advantage to a system distributing a large aggregate of power to many small users. We shall all look with great interest to the result of actual trial. The electrical railways at Berlin, in Paris, and in Ireland, and Edison's road at Menlo Park, are not likely to remain long unoccupied. Our own elevated railroad system offers the best possible field for the utilization of this system; and the often proposed scheme of burning all our fuel at the mine, and transmitting light, heat, and power to our cities along electrical conductors, begins to seem almost a practicable one. We may begin to look once more to thermo-electrical generation as a possible method of transformation at the source of power, as proposed by our distinguished colleague, Farmer, years ago. The fact that, while a 4-horse-power dynamo deposits about 700 pounds of copper in 24 hours, expending, say, 400 pounds of fuel, at least, in usual work, Farmer deposited 400 pounds of copper 20 years ago, nearly, with an expenditure of but 109 pounds of coal burned in his thermo-electric battery, is an important one to be kept in mind in this connection. We may, perhaps, look soon to see this branch of the subject again taken up, and a battery again constructed capable of melting tungsten, and of fusing 8 pounds of platinum in 20 minutes.

Before leaving this subject, it is pleasing to note that in the introduction of new electrical units, our great predecessor, James Watt, is accorded deserved honor, beside Ampere, Weber, Ohm, Coulomb, Volta, and Faraday, and that so barbarous a system of nomenclature is made a means of perpetuating the name of so great an engineer, as well as those of such great physicists.

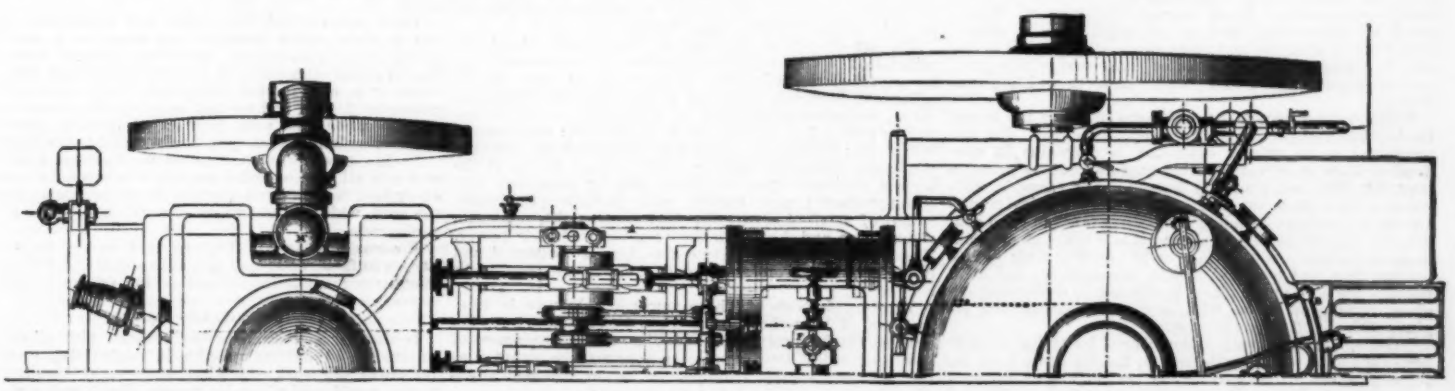


FIG. 3.—HALF PLAN VIEW.

IMPROVED FRENCH STEAM FIRE ENGINE.—FLAUD & COHENDET, BUILDERS, PARIS.

STEAM.

In *steam engine practice*, we are not now advancing rapidly. The introduction of the "drop cut off," in 1841, by Sickles; of the now standard type of automatic valve gear, in 1849, by Corliss; of the high-speed engine, twelve years later, by Allen and Porter; of the combined advantages of jacketing, superheating, and reheating; and the definite acceptance of the compound engine in later years, still constitute the complete history of modern steam engineering; but we are, nevertheless, continually gaining a knowledge of the best methods of handling higher steam; of attaining higher piston speed; of securing greater immunity from cylinder condensation and leakage; and of providing against other causes of waste. We are just beginning to perceive what principles must govern us in the endeavor to secure maximum commercial efficiency, and how economy in that direction is affected by the behavior of steam in the cylinder, and by the mutual relations of all the various expenditures that accompany the use of steam power.

The younger Perkinses are still leading in the practice of carrying high steam, and make 400 pounds per square inch —27 atmospheres—a usual figure, while they are experimentally repeating the work of the elder Perkins, and of Dr. Albans, of forty years ago, working steam at 1,000 pounds or nearly 70 atmospheres.

Unfortunately, the gain to be anticipated by the use of these enormously increased pressures does not seem likely to be very great, unless some decidedly less wasteful kind of engine can be devised in which to work it. The Anthracite, with steam at 300 pounds and upward, was less economical in fuel than the Leila, carrying about one-third that pressure. Emery has stated that a limit seems to be found at about 100 pounds to economical increase of pressure; and Stevens finds a limit, due to the geometrical character of the indicator diagram, inside of 250.

One of the most interesting and curious as well as important deductions from the rational theory of engine efficiency is the existence of an "absolute limit to economical expansion"—lying far within the previous accepted limit—due to the fact of increase of cylinder condensation and waste with increase in the ratio of expansion, which places an early limit to the gain due expansion *per se*. It seems possible, if not certain, that this point is often actually reached in ordinary engines within the range of customary practice.

All these facts combined point to a probability that we have little to hope for in the direction of increased steam engine economy with our standard machinery. Change in the directions that I have already so often indicated are evidently to be our sole reliance—changes limiting loss by cylinder condensation. Probably the surrounding of the working fluid by non-transferring surfaces is our only resource, in addition to, or in substitution for, the now well understood expedients of high piston speed and superheating. Until that is done, steam jacketing remains a necessary and unsatisfactory method of reducing losses. With a non-conducting cylinder, were it procurable, we might secure very nearly the efficiency of the ideal engine, friction aside as it would be a "perfect engine," and no natural limit would then exist to increasing economy. Were this accomplished, we might at once reduce the cost of steam power by about one-half in our best engines, and to probably one-fourth or one-fifth the present cost in ordinary machines.

In steam engineering, both physicists and engineers are more than ever attracted to the study of those phenomena which produce the familiar and enormous differences, even in the best practice, between the thermo-dynamic and the actual efficiencies of engines. The subject lies in that "march land" territory between science and practice, which few of the profession can explore from both sides, and it has remained less known than it would otherwise be were it either a matter of purely physical science or of practical experience. Fortunately, we are likely soon to see it thoroughly studied. The debate which arose not long since between Zeuner, the distinguished physicist, as a representative of pure science, and Hirn, the no less distinguished engineer, as an experienced practitioner and skillful experimentalist, in which the differences, to which I have so often called attention, of fifty per cent, or more between the "theoretical" efficiency and the actual performance of the best steam engines seem for the first time to have been given prominence in Europe, has led to a much closer study of the matter than could possibly otherwise have been brought about.

On this side the Atlantic, the discussion of steam engineering efficiencies has been carried on earnestly, if not always with that knowledge that should precede criticism, and it is to be hoped and anticipated that the engineer may ere long be put in possession of positive facts and real knowledge that may aid him in so designing and so applying this greatest of modern inventions as to attain the *maximum maximorum* of economy.

Ten years ago, nearly, I took occasion to state, in a report to the President of the United States on the exhibited machinery of the Vienna exhibition of 1873, printed later with the other reports of the United States Scientific Commission, that "The changes of design recently observed in marine engines, and less strikingly in stationary steam engines, have been compelled by purely mechanical and practical considerations. The increase noted in economy of expenditure of steam and of fuel is, as has been stated, due to increased steam-pressure, greater expansion, and higher piston speeds, with improved methods of construction and finer workmanship. These several directions of change occur simultaneously, and are all requisite. To secure maximum economy for any given steam-pressure, it is necessary to adopt a certain degree of expansion which gives maximum economy for that pressure under the existing conditions.

"This point of cut-off for maximum efficiency lies nearer the beginning of the stroke as steam-pressure rises. For low pressure a much greater expansion is allowable in condensing than in non-condensing engines; but, as pressure rises, this difference gradually lessens. For example, with steam at 25 pounds by gauge, the best economical results are obtained when expanding about three times in good condensing engines and about one and a half times in non-condensing engines. With steam at 50 pounds, these figures become five and two and a half, respectively; and at 75 pounds, the highest efficiency is secured in condensing engines, cutting off at one fifth, and in non-condensing engines with cut off at one-third stroke.

"Owing to the decreasing proportional losses due to back-pressure and to retarding influences, the departure from the economical result indicated for the perfect engine becomes greater and greater, until, at a pressure of between 200 and 250 pounds, the proper point of cut-off becomes about one-sixth or one-seventh, and very nearly the same for both classes of engines, and the increase of efficiency by increase of pressure and greater expansion becomes so slight as to indicate that it is very doubtful whether progress in the direction of higher pressure will be carried beyond this limit."

These conclusions were derived from careful observation of the performance of unjacketed "single cylinder" engines and a comparison of the ratios of expansion of those exhibiting greatest economy. It is interesting to note that later and probably more reliable methods of comparison than were then familiar go far in confirmation of the opinion then expressed. I think that I have been able to prove the existence, as just stated, of an "absolute limit of economical expansion," which, whatever the ratio of steam pressure to back pressure, in all ordinary heat engines probably falls within the range of familiar practice. Advance beyond the best efficiency of to-day in ordinary engines seems likely to be very slow and not at all likely ever to be very great.

Extended experiments will be needed to secure all the facts demanded by the designing engineer, and to furnish constants for the approximate theory of efficiency, which only is, as yet, his sole guide. An exact theory is one of those things for which he hopes, but which he does not expect soon to see. Some experiments have already been made, but they contribute only the first step. Those made by order of the Navy Department, and principally by Isherwood, and those of Hirn have hitherto been our sole guide, but a new line of more direct investigation of the laws governing internal, or cylinder, condensation has been inaugurated by Escher, of Zurich, and we are able to see a fair prospect of obtaining definite information in this direction.

Escher finds, in the case taken by him, that this waste varies nearly as the square root of the period of revolution and of the pressure, and is nearly independent of the back pressure—conclusions which are especially interesting to me as corroborating assumptions, based on general observation and non-experimental practice, made by me previously in developing an empirical system of design.

In steam boiler engineering, the only observable change seems to be the slow but steady gain made in the introduction of water-tube coil boilers and sectional boilers and in the extension of a rational system of inspection and test while in operation. To-day, the intelligent owner of boilers secures inspection and test, with insurance, by intelligent engineers and responsible underwriters, as invariably as he obtains inspection and insurance of his buildings. Under this system, steam boiler design, construction, and management is becoming a distinct art, based upon real knowledge. The system of forced circulation proposed by Trowbridge, and, perhaps, others, seems to me likely to prove useful in the solution of the problem to-day presented.

MARINE ENGINEERING.

In *naval architecture and marine engineering*, the fruits of the labors of our colleagues are seen in the constantly growing magnitude of our steamships, and in the steadily increasing celerity and safety which mark their unceasing transit from continent to continent.

The Alaska makes trip after trip, as regularly as a ferry boat in all but the most trying weather, from Sandy Hook to Queenstown in a week, and has made 18 knots an hour for 24 hours together, and the Arizona and the Servia are closely rivaling this wonderful performance.

A half dozen years ago I was consulted by an enterprising steamship proprietor who desired to learn how far the substitution of steel for iron would aid in the attainment of his aim—the construction of a line of steamers to make 25 miles an hour from shore to shore A similar project has been lately discussed, and it would not be surprising to the well-informed engineer if the plan is carried out within this decade.

Even the ill-famed line between Dover and Calais, and other channel routes, are benefiting at last by the achievements of the mechanical engineer, and the Invicta, a steamer considerably smaller than the Prilgrim, has crossed the channel in fair weather in a little over one hour running time—a speed of 18 knots or 21 miles an hour—and the "twin" steamer, Calais-Douvres, makes the passage in an hour and a half so steadily that the trying scenes so unpleasantly remembered by every unfortunate who has crossed on the old boats no longer occur.

This most attractive and difficult of problems presented to the engineer—*to secure a maximum speed combined with good cabin accommodations and paying cargo capacity*—demands an extent of knowledge and experience, an ingenuity and a degree of practical skill which are demanded by no other task set before the engineer.

My attention has been called to this subject more strongly than ever before by experiences arising recently in my own practice, and I have been interested in observing how largely the problem resolves itself into one of boiler concentration. The engineering of the machinery is a minor matter; to get a maximum of steam production from a minimum space and weight in the boiler room and coal-bunker compartment is a vitally important matter. Even where the cargo space is surrendered, it is difficult to secure speed and good cabins in small steamers, and the scheming of a high speed yacht of ample accommodations and of good sea-going qualities is a most perplexing piece of work.

Not the least remarkable work in this department has been done, however, on very small craft. Torpedo boats require but little weight—carrying displacement—and can be loaded with machinery, and thus the disadvantage of their small size is, partly at least, compensated. They have been given astonishing speeds, but only by forcing boilers tremendously to drive the lightest of engines in the lightest possible hulls over, rather than through, the water.

The art of getting high speed is extremely simple in principle, but very difficult in practice. It embraces a very few essential requirements: (1) Lightness of hull; (2) excellence of form; (3) minimum weights carried, whether in cargo, accommodations, fuel, or machinery; (4) great impelling power, *i. e.*, for best work, a steel hull; small cargo; few stores; fuel for the least time permitted by ordinary prudence; contracted cabins; small engines driven at the highest attainable speed of piston and by maximum safe steam-pressure; and finally, and perhaps principally, boilers of small size, carrying high steam, with minimum water space and forced to the very limit of their power. The art of getting large grate area into a contracted and peculiarly-shaped cross-section of hull is one still to be learned.

The torpedo boats of Thorneycroft and Yarrow in England and of Herreshoff in the United States illustrate the most successful practice of to-day, and their attainment of speeds exceeding twenty miles an hour may be accepted as the most remarkable triumphs of recent mechanical engineering.

With light hulls, weighing but about one-third their displacement, having such fine lines as to occupy but six-tenths the circumscribing cylinder, burning 100 to 150 pounds of fuel on the square foot of grate, carrying 120 pounds of steam, their little engines making 800 to 900 feet of piston speed per minute, at from 500 to 700 revolutions, and weighing but 50 or 60 pounds to the horse power, this kind of work is locomotive practice of the most radical sort. The secret of success here lies largely in ability to drive the boilers, which are of the locomotive type, forced by powerful fan "blowers," and give a horse power to each 1½ or 2 square feet of heating surface, and from 20 to 30 horse power to the square foot of grate.

Now that we are using surface condensation exclusively, there is comparatively little difficulty in the introduction of locomotive practice at sea.

But remarkable and important as is this phase of steam engineering, these little craft have revealed in their performance facts of equal importance in another department. The speeds attained are high, even for large ocean steamers; they are enormously high for such small vessels. It is found that, passing the speeds of 10 or 12 knots, which correspond to high speeds in larger craft, the rate of variation to resistance passes a maximum, and then falls from variation as the cube of the speed, or higher, to the ⅔ power, and becomes finally directly proportional to the speed at their highest velocity, thus giving a comparatively economical performance.

Should the same change of law occur with large steamers, maximum railroad speeds at sea may yet prove to be attainable, when, as I have no question will, ere many years, be the case, we shall burn at sea a hundred and fifty pounds on the square foot of grate in locomotive or sectional boilers, with steam at 200 or 300 pounds pressure, driving engines at 1,000 or 1,500 feet piston speed per minute, turning screws fitted with guide blades as already practiced abroad, and with machinery of steel in steel hulls of less proportional weight than these torpedo boats.

It is by such changes as these that the mechanical engineer and his colleagues in the trades is gradually revolutionizing the art of war. Before many years, we hope, war will be made so destructive that no nation will dare venture into a naval contest, and the engineer will have then entitled himself to the glorious distinction of being victor over victory itself. He may thus bring about the death of all war, and may give new meaning to Schiller's song:

"Honor's won by gun and saber;
Honor's justly due to kings;
But the dignity of labor
Still the greatest honor brings."

The screw has become the only instrument of propulsion where it can be used, and I can see no reason to suppose that it will not so remain indefinitely; but engineers, who have hitherto been blindly groping to find some new and peculiar form which may possess mysterious principles of efficiency, have now become fully cognizant of the analogy between the screw propeller and the turbine, and are seeking to apply the well-developed theory of the latter to the former.

The value of a system of guide blades and of methods of direction of the currents approaching and leaving the screw is being determined experimentally, and it is to be hoped that, before long, we may see this instrument rival the better classes of turbine and exhibit an efficiency of 80 per cent and upward. Thorneycroft has already done good work in this direction.

AERONAUTICS.

It is the reduction of weight of hull and machinery, so remarkably exemplified in recent naval engineering, and the no less remarkable recent improvement in performance, that render it more than possible that we may be on the eve of real advancement in *aeronautics*.

In my last address, I referred to the work done up to that date, and endeavored to show how far the researches of Marey, of Pettigrew, of De Lauey, and Haughton had developed the experimental science of *aeronautics*, and how far the efforts of Dupuy de Lôme had supplemented the labors of the brothers Montgolfier, of Charles, of Greene, of Flammarion, and of Glaisher in actual navigation of the air. I took occasion to indicate what seemed to me to be the promise of the early future and the indications of ultimate success.

Since then, little or nothing has been done, either in research or in aeronautic practice, but Pole has made a study of the problem, and from known data has determined what we may probably expect to see accomplished when, as may soon occur, the modern methods of locomotive and marine engineering shall be applied to aerial steam navigation by means of balloons He studies the problem as outlined by Lavoisier, a century ago, 1783, as attacked by Giffard a generation ago, in 1850, and as so nearly solved by him and by Dupuy de Lome during the Franco-German war. Both attained speeds of between six and seven miles an hour in "*derigeable*" balloons.

Calculating, from known data, the necessary size of balloons to carry the demanded weights, obtaining by direct reference to known performance the probable resistance of the air-ship, taking the possible least weight of motor at 40 pounds per horse-power, net, 50 pounds gross, and 75 pounds including the condenser, and allowing for nearly 20 tons of cargo, Pole finds that a balloon, of spindle form, 100 feet in diameter and 370 feet long may be driven by this torpedo boat style of machinery at the rate of about 30 miles an hour An air ship of one-half these dimensions would steam 20 miles, and one built on one-third scale 12 miles an hour.

These are certainly interesting and remarkable figures; but, as their author remarks, they come fairly and legitimately from existing data. Should the time ever come when the practical difficulties of construction can be fully overcome, it is evident that success in aerial navigation will promptly follow, and we may hope that the time is not far distant when this new product of modern mechanical engineering may become practically useful to the world.

To-day, however, man, with all his vaunted intelligence and with all his wonderful powers, is in this field beaten by every bird that flies and even by the so minute an insect as the gnat, which is only to be seen when disporting in the sunbeams.

Elmirus and Joseph Degnan have, as yet, no followers known to fame, and stand beside Bushnell and Fulton, who inaugurated submarine navigation, but yet are without successors.

CAPITAL AND LABOR.

In singular and discreditable contrast with all this gain in recent and current practice in engineering stands one feature of our work which has more importance to us and to the world, and which has a more direct and controlling influence upon the material prosperity and the happiness of the nation than any modern invention or than any discovery in science. I refer to the *relations of employers to the work-*

ing classes, and to the mutual interests of labor and capital. It is from us, if from any body of men, that the world should expect a complete and thorough satisfactory practical solution of the so called "labor problem." More is expected of us than even of our legislators. And how little has been accomplished!

Yet it would seem that the principles involved are simple, and that the practical difficulties should be readily overcome. The right of every man to buy or sell labor wherever and whenever he may choose and wherever and whenever he can make the best bargain is one of those rights which are natural and inalienable. The right of every man to engage in any occupation, or to enter into any department of honest industry, to train his children for any productive occupation, or to secure for them any kind of employment, is an equally natural and inalienable right. The privilege of accumulating property to any extent and by any honorable and legitimate means is also naturally and legally accorded to every citizen. It would seem obvious that one of the first claims of the citizen upon the State is that he shall be absolutely assured of these as constitutional rights. Any infraction of such rights and any attempted contravention of such privileges, whether by individuals, by legally constituted corporations, or by associations unknown to the law, should be promptly dealt with, and so severely, whether the culprit be of high or low degree, that the offense shall not be likely to be repeated.

No legislation should be permitted that shall injuriously affect any morally unobjectionable industrial enterprise or that shall impede any fair commercial operation, whether in the exchange of commodities or the transfer and use of capital. Only such a tariff system, even, can be safely permitted as shall encourage fairly the growth of such new industries as are adapted to our climate, soil, and other natural conditions.

The prosperity of a people is dependent upon their industry, integrity, skill, and enterprise, as well as upon the natural resources of the country; and the object of every government and of all legislation is to protect the people in their right to a fair reward for their industry, skill, and enterprise, to promote that mutual confidence that comes of real business trustworthiness, and to develop the natural resources and advantages of the State. The protection of the individual in his right to learn, to labor, and to traffic; the encouragement of natural enterprises, the diversification of industries, the promotion of the ability of the people to produce valuable materials and all kinds of products of the higher classes of skilled industry, the encouragement of invention and the making of the nation independent of all possible rivals or enemies in the production of whatever is necessary to the existence or the comfort of the people, are all perfectly proper objects of legislation. No legislation which neglects or opposes these objects can aid us. No legislation can serve the nation which aims to help either the employer or the employe, either the capitalist or the laborer, *alone*. No industry can permanently succeed which does not make both classes prosperous, and no statecraft is deserving the name which does not aim at the support of both. If either is discouraged and driven out of the field, business ceases and suffering results.

Again, force and intimidation have no place in matters of business. All legitimate operations, whether in commerce or manufactures, are the result of mutual agreement for mutual advantage. Strikes and lockouts, as well as their usual but shameful concomitants, intimidation and violence, are wholly out of place in our industrial system, and should be repressed by every legal means as absolutely opposed to the spirit of civilization and to the letter of our Declaration of Independence. The simplest principles of political economy and social ethics cover this matter fully. Labor, like any other salable possession, will have a value determined accurately by the great law of supply and demand, and the interruption of traffic in labor, and at the same time the compulsory interruption of production, in the end only result in serious injury to both parties to the controversy and to the whole country as well.

The introduction of a general system of arbitrament, the formations of unions between associated employers and of associated employes, the diversion of the trades unions into their legitimate channels of usefulness, will ultimately, we may be sure, effectually reform all the existing abuses in this direction. Already workingmen are learning that strikes almost invariably cost far more than they gain; capitalists are beginning to understand that their pecuniary interest, as well as ordinary humanity, dictate careful consideration of and respect for the rights and interests of labor; and, ere long, when employers sustain labor exchanges in all our great cities, and when trades unions confine themselves to benevolent enterprises and the assistance of those members who desire to reach better paying fields of labor, we may expect to see every industry settle down to a steady, unintermitted routine which will give maximum production, while every worker will have uninterrupted employment at rates of pay which will be the maximum value of the labor sold. If every boy were made familiar with Nordhoff and every man with Adam Smith and Spencer and Stuart Mill, we might hope that it would become universally understood that highest prosperity can only come when business can proceed without interruption by strikes, lockouts, or unintelligent legislation. A perusal of Eaton's excellent report on civil service suggests the thought that such a system is as desirable in every industrial organization as it is in the public service.

Grimm, in his life of Michael Angelo, says that three powers rule every state, and they are variously classed as "Money, Mind, Authority," as "Citizenship, Science, Nobility," or "Energy, Genius, Birth." I would say, in each individual, "Talent, Power, and Character," or "Genius, Strength, Integrity" are ruling powers, but that we are yet to see them rule the state. That the time is coming we may, I am sure, both hope and believe, but a great change must first take place.

We need a Junius to write, a Burke to speak, and a Chatham to illustrate a real reform.

The elements of social economy are yet to become known to our people; the most obvious principles of statesmanship are yet to be learned by our legislators, and we have still to look forward to a time when our men of business and our working people shall be fairly and respectfully considered by those who direct public policy. Before the needed reform can be made productive of general good, we must return to the original theory of our government—that all government has for its object simply the preservation of the rights of the people in their pursuit of the best life, the highest liberty, and the purest happiness; that it should guarantee to all, of whatever race, creed, powers, or sex, a common right to live, to learn, to labor, and to acquire and hold property, with absolute freedom of thought, speech, and right-doing.

To attain all that we desire and to secure highest efficiency in our political and social system, we must have a business man's and a working man's government. The professional politician and the machine system must become extinct. Our public policy and our law making must be made subservient to industrial interests. The people, and not self-seeking ward politicians, must frame the code and direct the expenditure of public funds.

SYSTEMATIC PROMOTION OF INDUSTRIES.

And these considerations bring up the question: How can so desirable a change in politics and in industry be brought about?

There is but one answer: By systematic and carefully planned encouragement of all industries; a system that shall illustrate those methods which are the true object of all government; a system, also, which shall supply means by which full advantage may be taken of all those opportunities which present themselves to every citizen of the United States.

Such bodies as this must aid our legislative assemblies in developing a *scheme of industrial organization* that shall exhibit highest possible efficiency—one that will prepare the children and youth of the country to enter upon lives of maximum usefulness, and to do the work that may be given them to do with ease and comfort, while at the same time aiding them to attain health, happiness, and content, even if not independence and wealth.

It is easy to see what must be the leading features of such a system. Since the prosperity of the state and of the people depends upon the integrity, the skill, and the industry of its citizens, it is evident that the cultivation of good morals, a keen sense of right, and a high sense of honor are primary requisites; that the instruction and training of every youth in the art for which he is best fitted is essential; that a fair general education is equally necessary to afford sources of intellectual pleasure; that a reduction of the hours of labor to a minimum healthful length must give opportunity for continual self-improvement and for healthful recreation.

It is obvious that we must find ways of encouragement of those industries, the success of which are best assured by our climate, our soil, our topography, and by our social and political conditions. We must take steps to secure by systematic legislation and by every other proper means a diversification of skilled industries and such a relative distribution of agricultural and manufacturing population as shall bring to each all the necessaries and comforts of life at minimum cost.

It is our task to study the soils, climates, and natural resources of this wide land of ours, to learn what products of the soil and what manufactured articles can be made to give the best return for time and money invested, and then to systematically develop by public policy and private enterprise every such industry, securing the highest skill, the most reliable labor, and the finest artistic talent by conscientiously cultivating them. Skilled labor has a steadier market, and makes a steadier market than unskilled, and our effort should evidently be to lead the world in its development, cultivating all profitable manufactures which demand greatest skill and highest talent; encouraging a varied industry; making the expenditure of capital and labor on transportation and on coarse work a minimum; and making the most of every pound of raw material brought into our market before putting it on sale again. Any system of encouragement of domestic industries that may be adopted must evidently include a practical and fruitful plan of careful education and of regular training in the trades and arts capable of successful growth among us, making our people the equals, and, if possible, the superiors, of their competitors in other countries in intelligence, skill, knowledge, and enterprise. It must introduce new industries and diversify old ones. It must teach the child, train the youth, and protect the man from excessive outside rivalry.

Only when our whole population has become as intelligent, as skillful, and as well informed in every branch of every industry, existing or arising in the state, as any other people can possibly be, only then may we rely safely upon profiting fully by all those advantages due to our natural position and resources.

Such a plan must be carefully considered by the sages of the community, and only adopted after deliberate study and thoughtful consideration. But a few general principles are readily discoverable. A half a dozen years ago, at the request of a commission appointed by the State of New Jersey, of which commission I had the honor to be appointed secretary, I prepared a general outline of such a scheme as that which now interests us, and based it upon the following "platform":

Such a plan, to be satisfactorily complete, must comprehend:

A common school system of general education, which shall give all young children tuition in the three studies which are the foundation of all education, and which shall be administered under compulsory law, as now generally adopted by the best educated nations and states on both sides the Atlantic.

A system of special adaptation of this primary instruction to the needs of children who are to become skilled artisans, or who are to become unskilled laborers in departments which offer opportunities for their advancement, when their intelligence and skill prove their fitness for such promotion, to the positions of skilled artisans. Such a system would lead to the adoption of reading, writing, and spelling books in which the terms peculiar to the trades, the methods of operation, and the technics of the industrial arts should be given prominence, to the exclusion, if necessary, of words, phrases, and reading matter of less essential importance to them.

A system of trade schools, in which general and special instruction should be given to pupils preparing to enter the several leading industries, and in which the principles underlying each industry, as well as the actual and essential manipulations, should be illustrated and taught by practical exercises until the pupil is given a good knowledge of them and more skill in conducting them. This series should include schools of carpentry, stone cutting, blacksmithing, etc., etc., weaving schools, schools of bleaching and dyeing, schools of agricultural, etc., etc.

At least one poiytechnic school in every State in the Union, in which the sciences should be taught and their applications in the arts indicated and illustrated by laboratory work. In this school, the aim should be to give a certain number of students a thoroughly scientific education and training, preparing them to make use of all new discoveries and inventions in science and art, and thus to keep themselves in the front rank.

A system of direct encouragement of existing established industries by every legal and proper means, as by the encouragement of improvement in our system of transportation, the relief of important undeveloped industries from State and municipal taxes, and even, in exceptional cases, by subsidy. It is evident that such methods of encouragement must be adopted very circumspectly and with exceedingly great caution, lest serious abuses arise.

This system should comprehend, perhaps, a bureau of statistics, authorized, under the law creating it, to collect statistics and information relating to all departments of industry established, or capable of being established, in the state.

I would place, as the head of this whole system of aid and encouragement of all legitimate industries, a great central university of the useful arts and sciences, which should be the directing member of the whole organization, furnishing higher instruction to the son of every citizen who can find his way to it, supplying the polytechnic schools and colleges with the most learned and talented instructors, aiding by scientific investigations the development of every industry, and serving as an attractive nucleus around which should gather the great men of every department to serve the state in that highest of employments, the instruction and training of our youth, and by giving counsel to legislators and executive officers of every department of the government, in concert with our already established National Academy of Sciences.

Washington urged the creation of a national university, a primary object of which should be the education of youth in the science of government. Jefferson, also, urged the foundation of "a national establishment for education," and John Stuart Mill has said, "National institutions should place all things that are connected with themselves before the mind of the citizen in the light in which it is for his good that he should regard them."

Experience at home and abroad shows that systematically conducted schools of art, and trade schools, are vastly more efficient and economical in the education and training of youth than the best managed mill or workshop. Every operation can there be taught, and the learner made perfectly familiar with each detail, without causing the inconvenience and pecuniary loss which are sure to come with such an attempt in the shop.

Very much such a complete system of technical science of instruction and of industrial education has been incorporated into the Continental educational structure, and there places before every child in the land the opportunity of giving such time as the social position and pecuniary circumstances of its parents enable them to allow to devote to the study of just those branches which are to it of most vital importance, and to acquire a systematic knowledge of the pursuit which surrounding conditions or its own predilections may lead it to follow through life, and to attain as thorough a knowledge and as high a degree of skill as that time, most efficiently disposed, can possibly be made to give him There is here no waste of the few months or years of, to him, most precious time, which the son or the daughter of the humblest artisan can spare for the acquisition of a limited education. Every moment is made to yield the most that can be made by its disposition in the most thoughtfully devised way that the most accomplished artisans and the most learned scholars, mutually advising each other, can suggest. One day, in such schools as those here described, is of more value to the youthful worker than a week in the older schools, or than a month in the workshop or the mill. Thus, while the fact is recognized that a general and a liberal education is desirable for every citizen, the no less undeniable fact is also recognized that few citizens can give the time to, or afford the expense of, a symmetrical general course, and that the interests of the individual and of the state unite in dictating the provision of such systems and means of industrial education and training as are now actually provided.

It is in consequence of the adoption of an intelligent and extensive system of the character of that which I would propose for our own country that it has become now generally admitted that Germany is the best educated nation of the civilized world. (There is danger that the United States may, with reason, be reckoned the worst.) Germany is gaining a better industrial position daily; our own country is retrograding in all that tends to give manufacturing preeminence, except in the ingenuity, skill, and enterprise of its people; and the one great, the vital, need of our people is a complete, efficient, and directly applicable system of technical instruction and of industrial training, if they are to avoid the successful and impoverishing competition of nations which have already been given that advantage by their statesmen and educators a generation earlier. The question whether this comparison shall remain as startling and as discreditable to the people of the United States in future years as it is to-day is to be determined by the ability of our people to understand and appreciate the importance of this subject, by the interest which the more intelligent classes may take in the matter, and upon the amount of influence which thinking citizens and educated men and the real statesmen among our legislators may have upon the policy and the action of the general and the State governments. The promptness and energy which we may display in an effort to place ourselves in a creditable position among educated nations will be the truest gauge of the character of the people of the United States. Judged by her progress in this direction, Europe is far in advance of us in the most essential elements of modern civilization.

There, instead of standing aloof from each other, and instead of forgetting, as is too frequently the case in our own country, those great facts and those imperative duties which every statesman does, and which every citizen should, recognize, the governing and the educated classes have worked together for the common good, and have given Germany, especially, a vantage ground in the universal struggle for existence and wealth which is likely, in the future, to enable that country for many years steadily to gain upon all competitors.

Our own work, thus far, has been desultory, sometimes ill directed, and rarely thorough or systematic. Our "technical schools," so called, are often modified trade schools, and our few trade schools frequently aspire to the position of polytechnic schools, and both classes are confounded in the minds of very many, even in the profession, and their work is seldom done with that maximum efficiency which can only come of intelligent organization and definite aims and fields of work. So it happens that while the system of general primary education is more widely spread and more effective than in any country in the world, and while we have a larger number of schools, in proportion to population, than perhaps any other country, we are nearly destitute of trade schools, and have extremely inadequate provisions for industrial education of any kind and for any class of our people.

This system of preparation of every citizen for useful work and a prosperous life being adopted, there remains to

be considered what can be done to aid the great industries into the channels of which all this skill and training in the arts and applied sciences is to be directed.

GENERAL CONCLUSIONS.

A complete working system of preparation being inaugurated, all is done that can be done for the individual in the endeavor to place him on a fair vantage ground in the struggle for survival which is going on throughout the world. Beyond this, he must trust principally to his own intelligence, skill, industry, and frugality for success in the effort to secure the necessaries and comforts of life, and to acquire luxuries, a comfortable independence in old age, and the means of starting his children on a higher level than that which he has himself reached.

A plan for the encouragement of our industries and to secure permanent prosperity must include a general policy of legislation which shall aid the capitalist to safely invest his funds in manufacturing enterprises, or in agriculture, shall assist the working man and the working woman to find remunerative and permanent employment, shall protect every one in the right to sell his capital or his labor at the best market value, wherever and whenever he chooses to offer it, and to give and to take in fair bargains without let or hinderance.

Such a policy must sustain every good workman in the effort to secure a good price for his labor and every employer against every attempt to compel him to pay good wages for bad work or to surrender the control of his business or his property to any other man.

Legislation must be general, and must, so far as possible, avoid either direct or indirect interference with the natural currents of trade. It must facilitate, not obstruct, natural industrial movements. The welfare of the people, and not of any class, rich or poor, must be studied.

The fruit of such a system as I have outlined will be fully seen only when all our labor is skilled and intelligent; when all our directors of labor are familiar with the science of their art, and when our men of science are all men applying science.

Renan, in his autobiography, expresses his conviction that succeeding generations will be taught principally natural sciences, for the reason that the truths learned in their study have more importance to mankind and have a deeper interest than the facts of history or the accumulated stores of general literature.

Men of science and men of art, too, are becoming known and acknowledged as of most importance to mankind and as the principal reliance of the race in its terrible struggle against poverty, disease, misery, and death. The influence and the power of men who devote themselves to the study of the phenomena of nature, and of those who make useful application of a knowledge of nature's facts, laws, and forces, must inevitably and continually increase so long as civilization shall continue to advance.

The world will finally reward most nobly those who thus most nobly strive to forward its highest aims.

MOUSSERON'S SMOKE-CONSUMING, PIPELESS STOVE.

THE stove shown in Figs. 1 and 2 consists principally of a cylindrical fire-place of refractory clay containing the fuel, and of a circular grate into which is set a central pipe

FIG. 1.—IMPROVED SMOKE-CONSUMING, PIPELESS STOVE.

FIG. 2.—VERTICAL SECTION.

containing an infinite number of holes designed for carrying to the very midst of the fire a large quantity of very hot and much divided air. This central pipe brings about a strong draught, and, by dividing the air that enters through the grate-bars, causes the small currents to reach a very high temperature; so that, during very lively combustion, the formation of oxide of carbon is impossible, and the carbon of the fuel is entirely converted into carbonic acid. Carbonic oxide being the only deleterious gas, all danger is averted through its absence.

A water-space of annular form, always containing a certain quantity of water, surrounds the upper part of the stove, and is so arranged that the flames reach the surface of the water that it holds. This water, notwithstanding the high temperature of the fire-place, never boils, but merely undergoes a rotary motion due to vaporization being effected entirely in the upper stratum of the liquid. Under such conditions, the hot air and the products of combustion are precipitated into the water. The water thus purifies the products of combustion by absorbing the sulphureted gases that are given off by the coal, and moderates the activity of the fire-place by vaporizing the drops drawn over on the coals. Besides this, it impregnates the gases with moisture and keeps the apartment in a hygrometric state in keeping with the elevation of the temperature, while at the same time it brings about an equal distribution of heat throughout the entire space heated by the diffusion of steam in the atmosphere. The cover forms, in the interior and at the top, a concavity against which strike the currents of hot air that are saturated with water through the steam escaping from the water space, and which are thus again brought in contact with the steam to be be saturated anew, and to finally escape through the lateral apertures. There issues from this stove, then, a very intense flow of hot air, exempt from carbonic oxide, but containing a very small amount of carbonic acid so diluted in an excess of steam that it cannot injure respiration. The stove is mounted on casters, and carries at its base a movable ash-pan. The water-space is provided on one side with a curved tube for filling, and on the other with a purge cock.

SIPHONS, HOW TO ARRANGE.

By C. M. PERCY, C.E.

A SIPHON possesses no power, and can do no mechanical work—it cannot raise water from a lower level and permanently deposit it on a higher level. But it can take water from a higher level and place it on a lower level, and in doing so convey it over points higher than that from which it started. The siphon, theoretically, will, after the manner of the suction of a pump, cause water to rise over a point equal to an atmospheric column, namely, 34 ft., but like a

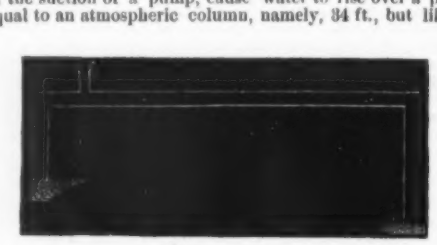


FIG. 1.—EFFECTIVE SIPHON PLACED LEVEL.

pump it works not beyond, in practice, 27 ft., should never have to work higher than 21 ft., and the less the height the better it will work. A siphon will not work unless the delivery is below the feed, and unless the pipes and joints are perfectly tight. If the line is not regular, as shown in Fig. 1 or Fig. 2, but irregular, as shown in Fig. 3, air collects at the high places, and the siphon ceases work. The writer, some years ago, was consulted as to gas from a mine making its way into siphon pipes and stopping the action. If this was so, it was simply that the gas made its way in along with the water, and had the same injurious influence as ordinary air. It may be useful to a reader here and there just to explain briefly the action of the siphon, and how to construct it and work it.

The siphon is a bent tube open at both ends, and having one leg less in vertical height than the other—see Fig. 4. If such a tube be filled with water, and placed with the extremity of the shorter leg in a vessel also containing water, the water will flow out through the longer leg. If the vertical height from the surface of the water in the vessel to the top of the siphon be the same as the height of the other leg, no delivery will take place, because the pressure of the atmosphere will be acting on two identical columns, which will exactly balance each other, and there will be no tendency to motion in any one direction more than the other. But if, as shown in Fig. 4, the vertical height from the level of the water in the vessel is greater than the vertical height of the other leg, equilibrium ceases. The atmospheric pressure is the same on both sides, but one column is longer than the other, and the water flows down that, causing a vacuum. The pressure of the atmosphere acting on the surface of the water in the vessel forces the water up the shorter leg to fill up this empty space. Thus motion begins and continues.

In constructing siphons, the first consideration is that the pipes and joints should be such as to prevent inward leakage of air, otherwise the appliance is useless. Then it should be laid as regularly as possible, either horizontally or inclined as already stated, because, if irregular, as shown in an exaggerated form in Fig. 3, air, which cannot be prevented entering along with the water, will lodge at the higher points, as shown shaded, and destroy the action. Of course, such a defect might partially be remedied by inserting a vertical pipe at each of these points, but it is better not to need them. Provision will have to be made for charging a siphon at the commencement, and occasionally when so much air has entered as to injure, if not stop the work. To do this, a tap is placed at the delivery end to be opened and closed by hand, and a light clack placed in the pipe at the feed end. This clack will open and keep open when the siphon is at work, and close when the tap is shut at the other end, thus keeping the siphon charged. Such a clack is not needed at all in the actual working; indeed, should be open the whole time, and if too heavy or carelessly made, will do harm. The idea is to keep the appliance charged when working has ceased. A pipe is inserted at the highest point, or nearly so, of the siphon, for the double purpose of charging and allowing air to escape.

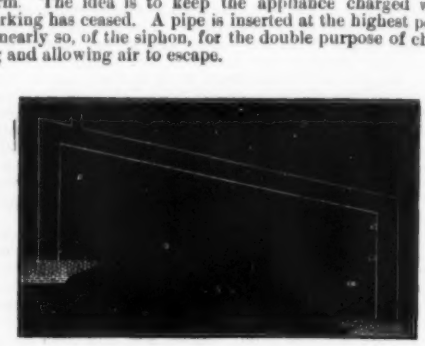


FIG. 2.—EFFECTIVE SIPHON, REGULAR INCLINATION.

In addition to using the siphon between sump holes and in other parts of mines, the writer found it of good service on at least two special occasions. One was during a fire which had broken out underground in the neighborhood of the furnace, and a stream of water was laid on from a reservoir on the surface. It was considered undesirable to cut through the reservoir bank, and the siphon enabled the water to be obtained from the reservoir over the bank. During this use of the siphon an interesting practical proof was obtained of the inertia of water bursting pipes. Almost every time the water was turned off suddenly one or more pipes burst, owing to the sudden check upon the flow of water; but when turned off gradually no damage was done. The other case was wanting to empty, or nearly so, a large and deep reservoir without cutting through the bank, the overflow being, of course, much too high. Again the siphon answered the purpose, and delivered the water into a

FIG. 3.—DEFECTIVE FORM OF SIPHON.

drain passing through some low-lying land. A siphon has its maximum efficiency when the height the water has to rise is a minimum and the vertical fall not less than the atmospheric column—34 ft. In such a case, the theoretic velocity would be obtained from the formula velocity in feet per second squared = twice gravitation × height in feet, or = 64 × 34 = 2,176, square root of which would be about 46½ ft. per second. This is the maximum velocity, and would be reduced by friction dependent on length and size of siphon. For other cases the effective height could never be more than 34 ft., minus the height the water had to rise, and this would still further be reduced by the extent that the length of the shorter leg was less than 34 ft.

Siphon at Waterworks.—An important local authority in Lancashire, having jurisdiction over some 20,000 people, has adopted the siphon, not directly for colliery purposes, but indirectly, inasmuch as it is used to supply water to a colliery population.

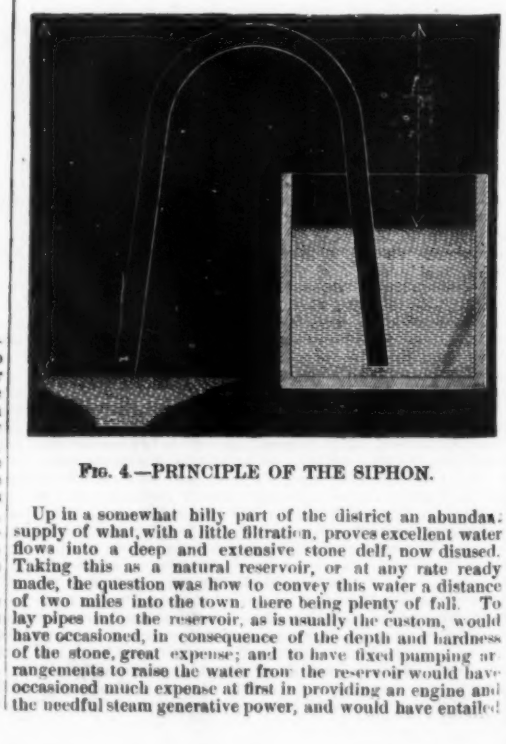


FIG. 4.—PRINCIPLE OF THE SIPHON.

Up in a somewhat hilly part of the district an abundant supply of what, with a little filtration, proves excellent water flows into a deep and extensive stone delf, now disused. Taking this as a natural reservoir, or at any rate ready made, the question was how to convey this water a distance of two miles into the town, there being plenty of fall. To lay pipes into the reservoir, as is usually the custom, would have occasioned, in consequence of the depth and hardness of the stone, great expense; and to have fixed pumping arrangements to raise the water from the reservoir would have occasioned much expense at first in providing an engine and the needful steam generative power, and would have entailed

some continuous expense afterward, which would not have been lessened by the fact that the site was high, far removed from railway conveniences, and the approaches bad.

Under all these circumstances, a siphon seemed just the thing for producing a maximum of effectiveness with a minimum of expense, and a siphon was accordingly placed. The short leg is vertical, and measures some 30 feet. The long leg forms an inclination of about half a mile long, with a vertical fall rather exceeding an atmospheric column, and discharges into a large filter bed. The pipes, being large, would, if working anything like continuously, empty the reservoir, and disorganize the siphon. Accordingly, a valve is fixed at the lower end of the long leg, and either allows full discharge or no discharge, or regulates the delivery to anything that may be required.

When the reservoir is what may be termed full, the water is within 12 ft. of the highest point of the siphon, and the work goes on well when the level of the water is anything between this and 21 ft. But when the vertical depth from the highest point of the siphon to the level of the water exceeds this 21 ft., the arrangement at once has a lessened efficiency. A pipe for the exit of air is fixed in accordance with the principles laid down in this article.

The writer has been much interested in this thoroughly useful application of a useful contrivance, because he was consulted on the subject when first proposed, and has had several opportunities of satisfying himself as to its efficiency during the few years it has been at work. All the pipes must of course be perfectly sound, and carefully and regularly laid, and the joints all made with great care. As a consequence, there has been and will be no trouble.

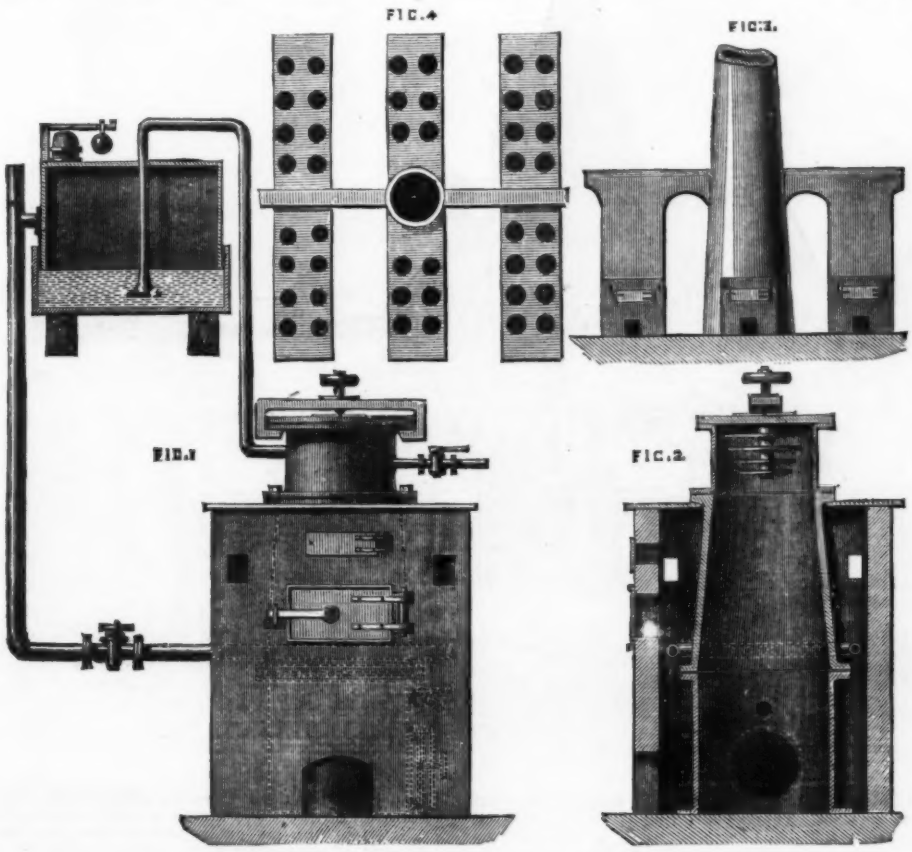
Such form our introductory remarks as to pumping arrangements, including, as was thought opportune, some particulars of that useful and close ally of the pump at collieries, namely, the siphon.—*Colliery Guardian.*

IRON DIRECT FROM THE ORE.

A PROCESS for making iron direct from the ore has been patented in England by Mr. J. C. Bromfield, Hove, Brighton, and described as follows:

The iron ore and fuel coal are reduced to a powder by a machine such as Blake's crusher, after having been calcined in ovens above a tank filled with water, into which the roasted ore passes direct from the ovens. The ore then becomes disintegrated and friable, and the cost of reduction afterward very small. The crushed iron ore and coal dust are then mixed, and to them is added carbonate of lime, which is also powdered ready for mixing, as well as alumina or sand. The proportions of each depend on the quality of the material used, and vary according to the nature of the iron in the different districts. The lime, however, will probably vary from one-tenth to one-eighth. The materials are then passed through a mixing machine, and brought into a plastic state by the admixture of mucilage, obtained from steaming seaweed in a close-jacketed boiler, the seaweed being afterward submitted to hydraulic pressure. The mucilage thus obtained has the effect of cementing the pulverized materials, which are discharged at the end of the cylinder into the hopper of a brick or tile making machine. The compressed materials issue from the machine, either as bricks or continuous solid cylinders, into trucks or barrows, and are removed at once to the retort, there to be consolidated into coke by a process of distillation in a furnace, which is illustrated in the annexed engravings. In these, Fig. 1 is a front elevation, and Fig. 2 a longitudinal vertical section of a furnace and retort. Figs. 3 and 4 show respectively an outline elevation and a ground plan of a series of furnaces and retorts, from which the gases are led and disposed of, either for lighting purposes or for being burnt as a fuel under the furnaces. The by products are in this manner to be saved.

The retorts are made in two parts; the lower, which is used as a cold coke chamber, is made of wrought iron; and the upper, which is conical in shape, is of fire clay, in combination with either carbonate of lime or calcium oxide. The object is to absorb the sulphur given off from the material being coked during the process of gas distillation. The lime, which should be in a caustic state and thoroughly blended with the particles of the fuel, should arrest and combine with any sulphur which may exist in the incorporated materials, while acting still more efficiently and quickly than it ordinarily does in forming a flux with the intermixed silica. Each block or brick of the compound will thus be subjected to cementation in a carbonaceous matrix, which is firmly held together by those ingredients which are intended to flux the whole mass when the melting zone of the furnace is reached. The saving in fuel and the increase in the output of each furnace are due to the same cause, the greater quickness with which the smelting reactions take place and the much lower temperature required.



BROMFIELD'S PROCESS OF IRON MAKING.

READING AND SPEAKING.*

By Prof. A. J. D. D'ORSEY, Lecturer on Public Reading at King's College.

ALL good reading was natural, and if asked what natural reading was, he (Prof. D'Orsey) would say: that which suits the nature of the speaker or reader, the nature of the thing read, or the nature of the place or circumstances in which it was read. What would suit an actor would be out of character in a clergyman, and *vice versa;* what would be quite proper in reading the Bible would not be the style for Shakespeare, and a Shakespearean style should certainly never be applied to the Bible. Mannerisms, with all the other faults of our public reading and speaking, should be carefully avoided. This was difficult, as was illustrated by an anecdote of Mrs. Siddons, who went to a shop for a pair of gloves, and asked, "Woman, hast thou gloves?" in such a tragic style that the shopwoman, trembling lest her customer were a mad woman with a dagger beneath her cloak, stammeringly replied, "Oh, please, madam, you may have all the gloves in the shop if you'll only spare my life."

The first thing to be reformed in schools, colleges, and everywhere else in this matter was attitude, to illustrate which Prof. D'Orsey imitated the attitude of a village school boy, with shoulders well up to his head, his chest flattened, and his book with both hands pressed lovingly and affectionately to his breast. (The attitude and the sing-song tone of the lecturer created roars of laughter.) A prevailing note, E, F, or G, sharp, flat, or natural, was the general characteristic of school boy or school girl reading in England. A similarly amusing sketch was given of public school reading. The "h's" were not dropped, and the tone was more gentlemanly, but there was equally unmeaning monotony.

Lastly, the reading of the ladies' school or college was illustrated—a niminy-piminy, namby-pamby style of reading, in a very low tone, with no expression, and with no manifestation of intelligence. Why should reading be thus defective? The attitude must be first reformed. The book should never be held with both hands—a little light octavo as if it were a ponderous folio. It should be held with the left hand slightly extended, the shoulders should be thrown back, the chest expanded, the windpipe straight, the chin at right angles to the windpipe, and the voice thrown to the end of the room. The cultivation of the voice for reading and speaking was at least as important as for singing. Prof. D'Orsey imitated a certain mayor, who introduced him in a speech which he bent over the table to deliver till at length there was a head near the table with two elbows up on each side of it, and said that to stoop while reading made twice as much exertion necessary. He reminded his brother clergy of the rubric before the first lesson: "Then shall be read distinctly and with an audible voice"—two very important provisos—"the first lesson, . . . he that readeth so standing and turning himself as he may best be heard of all such as are present." When did they see a clergyman turn himself during the reading of the lesson so that his voice might go all over the church? This rubric contained all the guidance necessary in the matter of attitude.

The next matter for reform was breathing: for although we were at that all our lives, we needed hints on the management of the breath. Some, by drawing in the breath every fourth or fifth word, laid the foundation of the disease of stammering, and bad breathing was at the bottom of much bad reading. A first principle was never to breathe through the mouth if it could be avoided. It dried the mouth, particles of dust were inhaled, with occasionally an enterprising fly, and the vocal organs were injured by turning the cold air upon them when they were in an excited and heated state. Medical men would bear him out in this. Let the mouth be kept tightly shut whenever possible, and let the air be inhaled through the nostrils, but let it be done quietly. It was important also to take a full breath; for when the lungs were fully inflated, the chest was a natural sounding board. To speak with a half-breath was to put great pressure on the vocal organs, croak like a frog, and ultimately ruin the whole voice. Fully inflate your chest, and you could say "Shoulder arms!" with a voice like thunder.

The voice was not sufficiently attended to in schools. Mr. D'Orsey gave examples to show that the same inflections and emphasis which were natural in ordinary conversation should be cultivated in reading aloud. It should be known that there were speech notes, just as there were singing notes. Did they ask what was the shortest way of learning to read naturally? He would say: if you were to divide yourself into two, as it were, and call one the reading man and the other the speaking man, and let the speaking man but teach the reading man, you would be sure to read well—the natural voice of the speaker would be transposed into the reader, and the dreary monotone and mismanagement of the voice would disappear. The voice, like everything else, was improved by cultivation and ruined by mismanagement. By training, it could be made as delicate, as sonorous, as musical, and as powerful for reading as for singing. On the other hand, out of 25,000 clergy more than 3,000 were on the shelf from physical derangements, the result of mismanagement of the voice. Men shouted instead of being distinct, and raised their voices instead of modulating them, and so ruined their vocal organs. He knew a clergyman who had two voices, who preached with a gruff bass voice, varied with an occasional falsetto. He had the misfortune to fall into an open grave. Said he, in his deep bass, "Is any one passing? I have fallen into this grave." "Where are you?" some one asked. "Here, down in this corner," said he, in his falsetto; whereupon he received the reply, "Oh, if there are two of you, you may help each other out."

Another necessity of good reading and speaking, Prof. D'Orsey said, was articulation. As a nation, compared with other nations of Europe, we were a most indistinct set of speakers. Out of this arose the habit which shopmen had of repeating an order given them. Every letter should be sharp and clear, so that not one word could be missed. A whisper ought to travel 300 or 400 feet, and to show the possibility of this, Professor D'Orsey stated that he had proved it in York Minster and in the large church of St. Michael's, Coventry, 300 feet long. Not only did he make other persons hear his whisper at Coventry, but he heard theirs the whole length of the church. He had also succeeded in such an experiment in the Albert Hall, and this showed that it was not loud, but distinct, speaking which did it. A lecturer who was very loud in his tones and very energetic was once rebuked by a quiet Quaker when he sat down. "Friend," said he, "before thou beginnest thy laborious work again, wilt thou allow me to say a word? Thou wilt not be offended if I say to thee that thou makest such a dreadful noise we cannot bear thee."

Indistinct articulation was an absurdity, and we should do well to remember Bishop Wilberforce's advice to his candidates for holy orders: "Spare your throats and use your lips." To teach pupils to articulate correctly, they must be shown what organs produced certain sounds. To pronounce one's "r's" properly, for instance, the tip of the tongue should be put at the back of the upper teeth, and then, by the pressure of air, removed and replaced, and the operation repeated. Let them attempt to say "rrrrrr," and they would soon know whether they pronounced it accurately. In the same way, the teeth must be used for d and t sounds, and the lips for five sounds, b, p, m, f, and v. Some people never used their lips at all, and to them he gave the advice he once gave to a young man who came to him—that they should go and seat themselves before a looking-glass and make all the faces they could think of.

As to pronunciation, it was another matter of importance, for which there was no real standard, but he recommended Walker's dictionary edited by Smart. A provincial dialect was a hard thing to encounter, but why not try to encounter it? As an instance of mispronunciation, he spoke of the Cockney "ai" or "i" for the sound of "a" in fate, remarking that out of 4,000,000 of people in London nothing like half a million people spoke respectable English.

Passing on to speak of the intellectual part of his subject, Professor D'Orsey said no man could read what he did not understand. He advised that before a piece was read a five minutes' lecture about it should be given to the class, that the boys and girls might understand what it was about. Then get them to mark with their pencils the words on which emphasis should be placed, to put a little tick like an apostrophe where a pause should be made, and a vertical stroke where a long pause should be inserted. Let them not say "It *was* a summer's evening, Old Kaspar's work was done," for nobody disputed the statement, but let them put a short quantity mark over "was" to show that the emphasis should be taken from that word. "Do you walk to Birmingham to-morrow at four o'clock?" was a sentence. *Do* you walk? Do *you* walk? Do you *walk* to Birmingham? Do you walk to *Birmingham* to-morrow? Do you walk to Birmingham *to-morrow?* Do you walk to Birmingham to-morrow *at four* o'clock? A different meaning was conveyed each time according to the position of the emphasis. There should never be an emphasis on personal pronouns except for a decided reason, nor on substantive or auxiliary verbs. In "Our Father which art in heaven," *art* should be spoken lightly and not with emphasis, for in a Christian congregation all believed that God was in heaven. In the creed, again, we heard it said, "The third day he rose *again* from the dead," whereas the emphasis should be on *rose*. At Sheffield that remark was disputed, but the chairman of the meeting undertook to answer the objection. He said he was out walking and saw a man building a wall. Later the same day he passed again, and the man being still at work he said, "There, you are building the wall again." "No," said he, "I'm only building it oonst." To take another instance, "Let there be light, and there was light" should be read "there was *light*," not "there *was* light."

* From a lecture delivered at Saxmundham.

Passing on to speak of pauses, Professor D'Orsey remarked some people stopped no more at commas than a steeplechaser did at a fence or ditch, and said that the beautiful Church Service was murdered by a neglect of punctuation which deserved the reprobation of every bishop or bishop's chaplain. Besides commas, there were rhetorical pauses where a slight check should be made—such as the pause between the nominative and the verb. Inflections must also be observed.

On the last division of his subject, the emotional, Professor D'Orsey said he would not pretend to teach his hearers; they must have heart in what they did. Sheridan Knowles told him, "I have taught you all that I know. There is one rule that covers it all—be in earnest. One flash of the eye—one hearty stroke of the arm—is worth a dozen sentences."

DESIGN FOR PREPARATORY SCHOOL FOR BOYS, WOOD GREEN, LONDON, ENG.

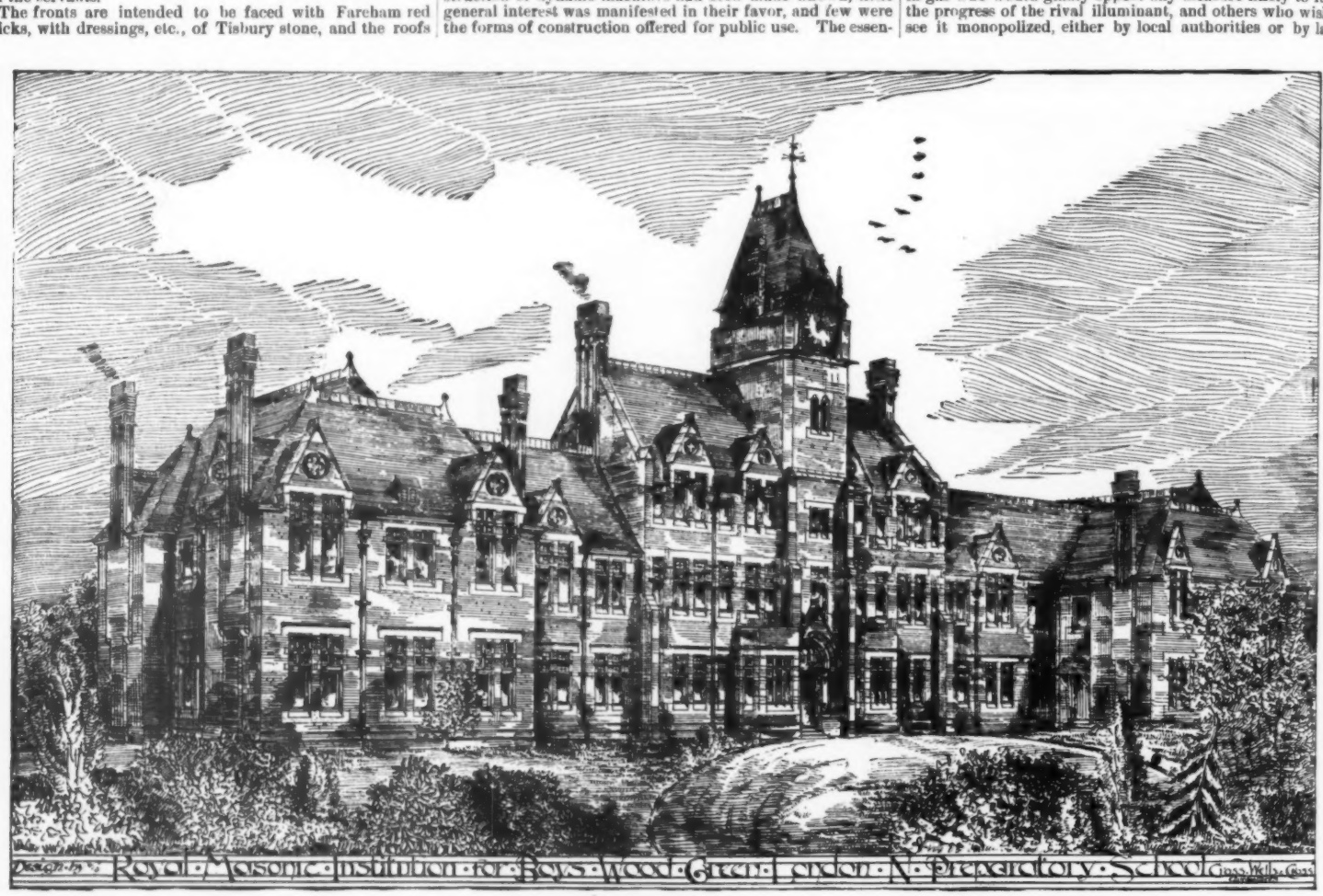
THIS design was prepared in accordance with conditions recently issued by the chairman and members of the House and Building Committee of the Royal Masonic Institution for Boys.

The drawings provide accommodation for 150 boys, and include, on ground floor, a central entrance hall and staircase communicating on either side (by a wide corridor running the entire length of the building) with class rooms, teachers' rooms, dining room, matron's, sitting, and store rooms, visitors' room, etc., and a dining hall. The boys' dormitories, etc., are placed on the first floor, and the second floor of the central block contains sleeping accommodations for the servants.

The fronts are intended to be faced with Farcham red bricks, with dressings, etc., of Tisbury stone, and the roofs covered with Bangor slates; the internal joiner's work to be in pitch pine.

The cost of the building and outbuildings, including inclosing fence, play sheds, gymnasium, etc., is estimated at £20,000.

Messrs. Cross, Wells & Cross, of No. 70 Chancery Lane, W. C., are the authors of the design.—*The Architect.*



ELECTRIC LIGHTING.—ITS COSTS AND APPLIANCES.*

By CHARLES WILLIAM SIEMENS, LL.D.

AMONG the practical questions that now chiefly occupy public attention are those of electric lighting, and of the transmission of force by electricity. These together form a subject which has occupied my attention and that of my brothers for a great number of years, and upon which I may consequently be expected to dwell on the present occasion, considering that at Southampton I could deal only with some purely scientific considerations involved in this important subject.

I need hardly remind you that electric lighting, viewed as a physical experiment, has been known to us since the early part of the present century, and that many attempts have, from time to time, been made to promote its application. Two principal difficulties have stood in the way of its practical introduction, viz., the great cost of producing an electric current so long as chemical means had to be resorted to, and the mechanical difficulty of constructing electric lamps capable of sustaining, with steadiness, prolonged effects.

The dynamo machine, which enables us to convert mechanical into electrical force, purely and simply, has very effectually disposed of the former difficulty, inasmuch as a properly conceived and well constructed machine of this character converts more than ninety per cent. of the mechanical force imparted to it into electricity, ninety per cent. again of which may be reconverted into mechanical force at a moderate distance. The margin of loss, therefore, does not exceed twenty per cent., excluding purely mechanical losses, and this is quite capable of being further reduced to some extent by improved modes of construction; but it results from these figures that no great step in advance can be looked for in this direction. The dynamo machine presents the great advantage of simplicity over steam or other power transmitting engines; it has but one working part, namely, a shaft, which, revolving in a pair of bearings, carries a coil or coils of wire admitting of perfect balancing. Frictional resistance is thus reduced to an absolute minimum, and no allowance has to be made for loss by condensation or badly fitting pistons, stuffing boxes, or valves, or for the jerking action due to oscillating weights. The materials composing the machine, namely, soft iron and copper wire, undergo no deterioration or change by continuous working, and the depreciation of value is therefore a minimum, except where currents of exceptionally high potential are used, which appear to render the copper wire brittle.

The essential points to be attended to in the conception of the dynamo machine, are the prevention of induced currents in the iron, and the placing of the wire in such position as to make the whole of it effective for the production of outward current. These principles, which have been clearly established by the labors of comparatively few workers in applied science, admit of being carried out in an almost infinite variety of constructive forms, for each of which may be claimed some real or imaginary merits regarding questions of convenience or cost of production.

For many years after the principles involved in the construction of dynamo machines had been made known, little general interest was manifested in their favor, and few were the forms of construction offered for public use. The essential feature involved in the dynamo machine, the Siemens armature (1856), the Pacinotti ring (1861), and the self-exciting principle (1867), were published by their authors for the pure scientific interest attached to them, without being made subject matter of letters patent, which circumstance appears to have had the contrary effect of what might have been expected, in that it has retarded the introduction of this class of electrical machine, because no person or firm had a sufficient commercial interest to undertake the large expenditure which must necessarily be incurred in reducing a first conception into a practical shape. Great credit is due to Monsieur Gramme for taking the initiative in the practical introduction of dynamo machines embodying those principles; but when, five years ago, I ventured to predict for the dynamo electric current a great practical future as a means of transmitting power to a distance, those views were still looked upon as more or less chimerical. A few striking examples of what could be practically effected by the dynamo electric current, such as the illumination of the Place de l'Opera, Paris, the occasional exhibition of powerful arc lights and their adoption for military and lighthouse purposes, but especially the gradual accomplishment of the much desired lamp by incandescence in vacuum, gave rise to a somewhat sudden reversion of public feeling; and you may remember the scare at the Stock Exchange, affecting the value of gas shares, which ensued in 1878, when the accomplishment of the subdivision of the electric light by incandescent wire was first announced, somewhat prematurely, through the Atlantic cable.

From this time forward electric lighting has been attracting more and more public attention, until the brilliant displays at the exhibition of Paris, and at the Crystal Palace last year, served to excite public interest to an extraordinary degree. New companies for the purpose of introducing electric light and power have been announced almost daily, whose claims to public attention as investments were based in some cases upon only very slight modifications of well-known forms of dynamo machines, of arc regulators, or of incandescent carbon lights, the merits of which rested rather upon anticipations than upon any scientific or practical proof. These arrangements were supposed to be of such superlative merit that gas and other illuminants must soon be matters simply of history, and hence arose great speculative excitement. It should be borne in mind, however, that any great technical advance is necessarily the work of time and serious labor, and that, when accomplished, it is generally found that, so far from injuring existing industries, it calls additional ones into existence to supply new demands, and thus gives rise to an increase in the sum total of our resources. It is therefore reasonable to expect that, side by side with the introduction of the new illuminant, gas lighting will go on improving and extending, although the advantage of electric light for many applications, such as the lighting of public halls and warehouses, of our drawing rooms and dining rooms, our passenger steamers, our docks and harbors, are so evident, that its advent may be looked upon as a matter of certainty.

Our legislature has not been slow in recognizing the importance of the new illuminant. In 1879, a select committee of the House of Commons instituted a careful inquiry into its nature and probable cost, with a view to legislation, and the conclusions at which they arrived were, I consider, the best that could have been laid down. They advised that applications should be encouraged tentatively by the granting of permissive bills, and this policy has given rise to the Electric Lighting Bill, 1882, promoted by Mr. Chamberlain, the President of the Board of Trade, regarding which much controversy has arisen. It could, indeed, hardly be expected that any act of legislation upon this subject could give universal satisfaction, because, while there are many believers in gas who would gladly oppose any measure likely to favor the progress of the rival illuminant, and others who wish to see it monopolized, either by local authorities or by large financial corporations, there are others again who would throw the doors open so wide as to enable almost all comers to interfere with the public thoroughfares for the establishment of conducting wires, without public let or hinderance.

The law, as now established, takes, I consider, a medium course between these diverging opinions, and if properly interpreted, will protect, I believe, all legitimate interests, without impeding the healthy growth of establishments for the distribution of electric energy for lighting and for the transmission of power. Any firm or lighting company may, by application to the local authorities, obtain leave to place electric conductors below public thoroughfares, subject to such conditions as may be mutually agreed upon, the term of such license being limited to seven years; or an application may be made to the Board of Trade for a provisional order to the same effect, which, when sanctioned by Parliament, secures a right of occupation for twenty-one years. The license offers the advantage of cheapness, and may be regarded as a purely tentative measure, to enable the firm or company to prove the value of their plant. If this is fairly established, the license would in all probability be affirmed, either by an engagement for its prolongation from time to time or by a provisional order, which would in that case be obtained by joint application of the contractor and the local authority. At the time of expiration of the provisional order, a right of pre-emption is accorded to the local authority, against which it has been objected with much force, by so competent an authority as Sir Frederick Bramwell, that the conditions of purchase laid down are not such as fairly to remunerate the contracting companies for their expenditure and risk, and that the power of purchase would inevitably induce the parochial bodies to become mere trading associations. But, while admitting the undesirability of such a consummation, I cannot help thinking that it was necessary to put some term to contracts entered into with speculative bodies at a time when the true value of electric energy, and the best conditions under which it should be applied, are

* From a presidential address before the Society of Arts, London, November 15, 1882.

still very imperfectly understood. The supply of electric energy, particularly in its application to transmission of power, is a matter simply of commercial demand and supply, which need not partake of the character of a large monopoly, similar to gas and water supply, and which may therefore be safely left in the hands of individuals or of local associations, subject to a certain control for the protection of public interests. At the termination of the period of the provisional order, the contract may be renewed upon such terms and conditions as may at that time appear just and reasonable to Parliament, under whose authority the Board of Trade will be empowered to effect such renewal.

Complaints appear almost daily in the public papers, to the effect that townships refuse their assent to applications by electric light companies for provisional orders; but it may be surmised that many of these applications are of a more or less speculative character, the object being to secure monopolies for eventual use or sale, under which circumstances the authorities are clearly justified in withholding their assent; and no licenses or provisional orders should indeed be granted, I consider, unless the applicants can give assurance of being able and willing to carry out the work within a reasonable time. But there are technical questions involved which are not yet sufficiently well understood to admit of immediate operations upon a large scale.

Attention has been very properly called to the great divergence in the opinions expressed by scientific men regarding the area that each lighting district should comprise, the capital required to light such an area, and the amount of electric tension that should be allowed in the conductors. In the case of gas supply, the works are necessarily situated in the outskirts of the town, on account of the nuisance this manufacture occasions to the immediate neighborhood; and, therefore, gas supply must range over a large area. It would be possible, no doubt, to deal with electricity on a similar basis, to establish electrical mains in the shape of copper rods of great thickness, with branches diverging from them in all directions; but the question to be considered is,

STOVE CHIMNEY IN ENAMELED EARTHENWARE DESIGNED BY A. ORTWEIN, GRATZ.

whether such an imitative course is desirable on account either of relative expense or of facility of working. My own opinion, based upon considerable practical experience and thought devoted to the subject, is decidedly adverse to such a plan. In my evidence before the Parliamentary committee, I limited the desirable area of an electric district in densely populated towns to a quarter of a square mile and estimated the cost of the necessary establishment of engines, dynamo machines, and conductors at £100,000, while other witnesses held that areas from one to four square miles could be worked advantageously from one center, and at a cost not exceeding materially the figure I had given. These discrepancies do not necessarily imply wide differences in the estimated cost of each machine or electric light, inasmuch as such estimates are necessarily based upon various assumptions regarding the number of houses and of public buildings comprised in such a district, and the amount of light to be apportioned to each, but I still maintain my preference for small districts.

By way of illustration, let us take the parish of St. James's, near at hand, a district not more densely populated than other equal areas within the metropolis, although comprising, perhaps, a greater number of public buildings. Its population, according to the preliminary report of the census taken on the 4th of April, 1881, was 29,865, it contains 3,018 inhabited houses, and its area is 784,000 square yards, or slightly above a quarter of a square mile.

To light a comfortable house of moderate dimensions in all its parts to the exclusion of gas, oil, or candles would require about one hundred incandescence lights (or, if I may suggest a more euphonious expression, glow lights) of from fifteen to eighteen candle power each, that being for instance, the number of Swan lights employed by Sir Wm. Thomson in lighting his house at Glasgow University. Eleven horse power would be required to excite this number of incandescence lights, and at this rate the parish of St. James's would require $3{,}018 \times 11 = 33{,}200$ horse power to work it. It may be fairly objected, however, that there are many houses in the parish much below the standard here referred to, but, on the other hand, there are 600 of them with shops on the ground floor, involving larger requirements. Nor does this estimate provide for the large consumption of electric energy that would take place in lighting the eleven churches, eighteen club houses, nine concert halls, three theaters, besides numerous hotels, restaurants, and lecture halls. A theater of moderate dimensions, such as the Savoy Theater, has been proved by experience to require 1,200 incandescence lights, representing an expenditure of 133 horse power; and about one-half that power would have to be set aside for each of the other public buildings here mentioned, constituting an aggregate of 2,926 horse power; nor does this general estimate comprise street lighting, and to light the six and one-half miles of principal streets of the parish with electric light would require, per mile, thirty-five arc lights of 350-candle power each, or a total of 227 lights. This, taken at the rate of 0·8 horse power per light, represents a further requirement of 182 horse power, making a total of 3,108 horse power for purposes independent of house lighting, being equivalent to one horse power per inhabited house, and bringing the total requirements up to 109 lights=12 horse power per house.

I do not, however, agree with those who expect that gas lighting will be entirely superseded, but have, on the contrary, always maintained that the electric light, while possessing great and peculiar advantages for lighting our principal rooms, halls, warehouses, etc., owing to its brilliancy, and more particularly to its non-interference with the healthful condition of the atmosphere, will leave ample room for the development of the former, which is susceptible of great improvement, and is likely to hold its own for the ordinary lighting up of our streets and dwellings.

Assuming, therefore, that the bulk of domestic lighting remains to the gas companies, and that the electric light is introduced into private houses, only, at the rate of, say, twelve incandescence lights per house, the parish of St. James's would have to be provided with electric energy sufficient to work $(9 + 12)\ 3{,}018 = 63{,}378$ lights $= 7{,}042$ horse

BRASS CANDLESTICK AND INKSTAND, DESIGNED BY PROF. CH. LACHER, GRATZ.—*From The Workshop.*

power effective; this is equal to about one-fourth the total lighting power required, taking into account that the total number of lights that have to be provided for a house are not all used at one and the same time. No allowance is made in this estimate for the transmission of power, which, in course of time, will form a very large application of electric energy; but considering that power will be required mostly in the day time, when light is not needed, a material increase in plant will not be necessary for that purpose.

In order to minimize the length and thickness of the electric conductor, it would be important to establish the source of power, as nearly as may be, in the center of the parish, and the position that suggests itself to my mind is that of Golden Square. If the unoccupied area of this square, representing 2,500 square yards, was excavated to a depth of twenty-five feet, and then arched over so as to re-establish the present ground level, a suitable covered space would be provided for the boilers, engines, and dynamo machines, without causing obstruction or public annoyance; the only erection above the surface would be the chimney, which, if made monumental in form, might be placed in the center of the square, and be combined with shafts for ventilating the subterranean chamber, care being taken, of course, to avoid smoke, by insuring perfect combustion of the fuel used. The cost of such a chamber, of engine power, and of dynamo machines capable of converting that power into electric energy, I estimate at £140,000. To this expense would have to be added that of providing and laying the conductors, together with the switches, current regulators, and arrangements for testing the insulation of the wire.

The cost and dimensions of the conductors would depend upon their length and the electro-motive force to be allowed. The latter would no doubt be limited by the authorities to the point at which contact of the two conductors with the human frame would not produce injurious effects, or say to 200 volts, except for street lighting, for which purpose a higher tension is admissible. In considering the proper size of conductor to be used in any given installation, two principal factors have to be taken into account; first, the charge for interest and depreciation on the original cost of a unit length of the conductor; and, secondly, the cost of the electrical energy lost through the resistance of a unit of length. The sum of these two, which may be regarded as the cost of conveyance of electricity, is clearly least, as Sir William Thomson pointed out some time ago, when the two components are equal. This, then, is the principle on which the size of a conductor should be determined.

From the experience of large installations, I consider that electricity can, roughly speaking, be produced in London at a cost of about one shilling per 10,000 ampère-volts or watts (746 watts being equal to one horse power) for an hour. Hence, assuming that each set of four incandescence lamps in series (such as Swan's, but for which may be substituted a smaller number of higher resistance and higher luminosity) requires 200 volts electro-motive force, and 60 watts for their efficient working, the total current required for 64,000 such lights is 19,200 ampères, and the cost of the electric energy lost by this current in passing through one one hundredth of an ohm resistance, is £16 per hour.

The resistance of a copper bar one-quarter of a mile in length and one square inch in section, is very nearly one one-hundredth of an ohm, and the weight is about 2¼ tons. Assuming, then, the price of insulated copper conductor at £90 per ton, and the rate of interest and depreciation at 7½ per cent., the charge per hour of the above conductor, when used eight hours per day, is 1⅛d. Hence, following the principle I have stated above, the proper size of conductor to use for an installation of the magnitude I have supposed would be one of 48·29 inches section, or a round rod eight inches diameter.

If the mean distance of the lamps from the station be assumed as 350 yards, the weight of copper used in the complete system of conductors would be nearly 168 tons, and its cost £15,120. To this must be added the cost of iron pipes for carrying the conductors underground, and of testing boxes and labor in placing them. Four pipes of ten-inch diameter each would have to proceed in different directions from the central station, each containing sixteen separate conductors of one inch diameter, and separately insulated, each of them supplying a sub-district of 1,000 lights. The total cost of establishing these conductors may be taken at £37,000, which brings up the total expenditure for central station and leads to £177,000. I assume the conductors to be placed underground, as I consider it quite inadmissible, both as regards permanency and public safety and convenience, to place them above ground within the precincts of towns. With this expenditure, the parish of St. James's could be supplied with the electric light to the extent of about 25 per cent. of the total illuminating power required. To provide a larger percentage of electric energy would increase the cost of establishment proportionately, and that of conductors, nearly in the square ratio of the increase of the district, unless the loss of energy by resistance is allowed to augment instead.

It may surprise uninitiated persons to be told that to supply a single parish with electric energy necessitates copper conductors of a collective area equal to a rod of eight inches in diameter; and how, it may be asked, will it be possible, under such conditions, to transmit the energy of waterfalls to distances of twenty or thirty miles, as has been suggested. It must indeed be admitted that the transmission of electric energy of such potential (200 volts) as is admissible in private dwellings would involve conductors of impracticable dimensions, and in order to transmit electrical energy to such

distances, it is necessary to resort in the first place to an electric current of high tension. By increasing the tension from 200 to 1,200 volts, the conductors may be reduced to one-sixth their area, and if we are content to lose a larger proportion of the energy obtained cheaply from a waterfall, we may effect a still greater reduction. A current of such high potential could not be introduced into houses for lighting purposes, but it could be passed through the coils of a secondary dynamo machine, to give motion to another primary machine, producing currents of low potential to be distributed for general consumption. Or secondary batteries may be used to effect the conversion of currents of high into those of low potential, whichever means may be found the cheaper in first cost, in maintenance, and most economical of energy. It may be advisable to have several such relays of energy for great distances, the result of which would be a reduction of the size and cost of conductor at the expense of final effect; and the policy of the electrical engineer will, in such cases, have to be governed by the relative cost of the conductor and of the power at its original source. If secondary batteries should become more permanent in their action than they are at the present time, they may be largely resorted to by consumers to receive a charge of electrical energy during the daytime, or the small hours of the night when the central engine would otherwise be unemployed; and the advantage of resorting to these means will depend upon the relative first cost and cost of working the secondary battery and the engine respectively. These questions are, however, outside the range of our present consideration.

The large aggregate of dwellings comprising the metropolis of London covers about seventy square miles, thirty of which may be taken to consist of parks, squares, and sparsely inhabited areas, which are not to be considered for our present purpose. The remaining forty square miles could be divided into, say, 140 districts, slightly exceeding a quarter of a square mile on the average, but containing each fully 3,000 houses and a population similar to that of St. James's.

Assuming twenty of these districts to rank with the parish of St. James's (after deducting the six hundred shops which I did not include in my estimate) as central districts, sixty to be residential districts, and sixty to be comparatively poor neighborhoods, and estimating the illuminating power required for these three classes in the proportion of 1 to ⅔ to ½, we should find that the total capital expenditure for supplying the metropolis with electric energy to the extent of 25 per cent. of the total lighting requirements would be—

20	×		177,000	=	£3,540,000
60	×	⅔	× 177,000	=	£7,080,000
60	×	½	× 177,000	=	£3,540,000
					£14,160,000

or say £14,000,000, without including lamps and internal fittings, and making an average capital expenditure of £100,000 per district.

To extend the same system over the towns of Great Britain and Ireland would absorb a capital exceeding certainly £64,000,000, to which must be added £16,000,000 for lamps and internal fittings, making a total capital expenditure of £80,000,000. Some of us may live to see this realized, but to find such an amount of capital, and what is more important, to find the manufacturing appliances to produce work representing this value of machinery and wire, must necessarily be the result of many years of technical development. If, therefore, we see that electric companies apply for provisional orders to supply electric energy, not only for every town throughout the country, but also for colonies and for foreign parts, we are forced to the conclusion that their ambition is somewhat in excess of their power of performance; and that no provisional order should be granted except conditionally on the work being executed within a reasonable time, as without such a provision the powers granted may have the effect of retarding instead of advancing electric lighting and of providing an undue encouragement to purely speculative operations.

The extension of a district beyond the quarter of a square mile limit would necessitate an establishment of unwieldy dimensions, and the total cost of electric conductors per unit area would be materially increased; but, independently of the consideration of cost, great public inconvenience would arise in consequence of the number and dimensions of the electric conductors, which could no longer be accommodated in narrow channels placed below the curb stones, but would necessitate the construction of costly subways—veritable *cava electrica*.

The amount of the working charges of an establishment comprising the parish of St. James's would depend on the number of working hours in the day and on the price of fuel per ton. Assuming the 64,000 lights to incandesce for six hours a day, the price of coal to be 20s. a ton, and the consumption 2 lb. per effective horse power per hour, the annual charge under this head, taking eight hours' firing, would amount to about £18,300, to which would have to be added, for wages, repairs, and sundries, about £6,000; for interest with depreciation at 7½ per cent., £13,300; and for general management, say £3,400; making a total annual charge of £41,000, or at the rate of 12s. 4½d. per incandescence lamp per annum. To this has to be added the cost of renewal of lamps, which may be taken at 5s. per lamp of 16 candles, lasting 1,200 hours, or to 9s. per annum, making a total of 21s. 9½d. per lamp for a year.

In comparing these results with the cost of gas lighting, we shall find that it takes five cubic feet of gas, in a good argand burner, to produce the same luminous effect as one incandescence light of 16-candle power. In lighting such a burner every day, for six hours on the average, we obtain an annual gas consumption of 10,950 cubic feet, the value of which, taken at the rate of 2s. 8d. per thousand, represents an annual charge of 29s., showing that electric light by incandescence, when carried out on a large scale, is decidedly cheaper than gas lighting at present prices, and with the ordinary gas burners.

On the other hand, the cost of establishing gas works and mains of a capacity equal to 64,000 argand burners would involve an expenditure not exceeding £80,000, as compared with £177,000 in the case of electricity; and it is thus shown that, although it is more costly to establish a given supply of illuminating power by electricity than gas the former has the advantage as regards current cost of production.

It would not be safe, however, for the advocates of electric lighting to rely upon these figures as representing a permanent state of things. In calculating the cost of electric light, I have only allowed for depreciation and 5 per cent. interest upon capital expenditure, whereas gas companies are in the habit of dividing large dividends and can afford to supply gas at a cheaper rate by taking advantage of recent improvements in manufacturing operations, and of the ever-increasing value of their by-products, including tar, coke, and ammoniacal liquor. Burners have, moreover, been recently devised by which the luminous effect for a given expenditure of gas can be nearly doubled by purely mechanical arrangements, and the brilliancy of the light can be greatly improved.

On the other hand, electric lighting also may certainly be cheapened by resorting, to a greater extent than has been assumed, to arc lighting, which, though less agreeable than the incandescence (or glow) light for domestic purposes, can be produced at less than half the cost, and deserves on that account the preference for street lighting and for large halls, in combination with incandescence lights. Lamps by incandescence may be produced hereafter at a lower cost, and of a more enduring character.

Considering the increasing public demand for improved illumination, it is not unreasonable to expect that the introduction of the electric light to the full extent here contemplated would go hand in hand with an increasing consumption of gas for illuminating and for heating purposes, and the neck-to-neck competition between the representatives of the two systems of illumination, which is likely to ensue, cannot fail to improve the quality and to cheapen the supply of both, a competition which the consuming public can afford to watch with complacent self-satisfaction. Electricity must win the day, as the light of luxury; but gas will at the same time find an ever increasing application for the more humble purposes of diffusing light.

In my address to the British Association, I dwelt upon the capabilities and prospects of gas, both as an illuminant and as a heating agent, and I do not think that I was over sanguine in predicting for this combustible a future exceeding all present anticipations.

I showed that if supplied specially for the purpose, it would become not only the most convenient, but by far the cheapest form of fuel that can be delivered to our towns. Such a general supply of heating separately from illuminating gas, by collecting the two gases into separate holders during the process of distillation, would have the beneficial effects—

1. Of giving to lighting gas a higher illuminating power.
2. Of relieving our towns of their most objectionable traffic, that in coal and ashes.
3. Of effecting the perfect cure of that bugbear of our winter existence—the smoke nuisance.
4. Of largely increasing the production of those valuable by-products, tar, coke, and ammonia, the annual value of which already exceeds by nearly £3,050,000 that of the coal consumed in the gas works.

The late exhibitions have been beneficial in arousing public interest in favor of smoke abatement, and it is satisfactory to find that many persons, without being compelled to do so, are now introducing perfectly smokeless arrangements for their domestic and kitchen fires.

The Society of Arts, which for more than one hundred years has given its attention to important questions regarding public health, comfort, and instruction would, in my opinion, be the proper body to examine thoroughly into the question of the supply and economical application of gas and electricity for the purposes of lighting, of power production, and of heating. They would thus pave the way to such legislative reform as may be necessary to facilitate the introduction of a rational system.

If I can be instrumental in engaging the interests of the society in these important questions, especially that of smoke prevention, I shall vacate this chair next year with the pleasing consciousness that my term of office has not been devoid of a practical result.

THE DANGERS OF ELECTRIC LIGHTING.

In the mill mutual insurance companies in New England, there were sixty-one establishments lighted by electricity up to last May. With few exceptions, the lights had not been in use previous to the fall of 1881, and many had been started early in the spring. In these sixty-one establishments, Mr. C. J. H. Woodbury records twenty-two fires due to electric lighting, and assignable to the following causes: Eight were from globules of melted copper or particles of hot carbon falling out from the bottom of the globes. The actual number of fires from this cause was probably many times this number. This class of fires will not continue to happen, as all makers now set their lamp globes in a tight stand with a ridge around the edge. A flat plate will not answer the purpose, as there was one instance where drops of melted copper rolled off and set afire. Four fires were due to leaking water or washing floors, and two more were caused by water in a dye-house condensing on the building to which uninsulated wires were fastened. In most of these instances, a grounded circuit formed one of the two connections necessary to divert the electricity from the wires. Many of the lower carbons fell from lamps, and five fires were caused where they fell upon combustible material. Three fires were caused by cross-arcs from one wire to another, where uninsulated wires were fastened against conductors. In one instance, the conductor was formed by dust settling upon uninsulated wires, and on a damp day it absorbed enough moisture to form a path for the formation of a cross-arc, which started a slight fire. In another instance, the wires were fastened to a damp beam, which was decayed, and was burned nearly in two by the smoldering fire. And in a third instance, damp brick-work in a tunnel was a sufficient conductor to establish an arc, which did not do any material damage there, but injured the dynamo. Two fires were caused by improper switches; two by water reaching the wires of a circuit already grounded; and one from wires coming in contact with a building, so that their insulation was worn away. Electricity forms the safest method of illumination when the following precautions are observed: The system insulated throughout, so that there is no electrical communication with the earth, or from one part of the apparatus to another, except through the proper conductors, even if the wires should be exposed to water; all switches made with lapping connection, so that no arc can be formed; arc lamps provided with globes closed underneath, and the frame so arranged that the lower carbon could not fall out, even if the clamp failed to hold it securely; the wires of incandescent systems provided with a sufficient number of fusible links to secure the system against any damage from an excess of current.

NOEL'S PRINTING TELEGRAPH.

THE printing telegraph apparatus of Dr. Noel, of Noyers St. Martin, Oise, France, was to have been exhibited at the International Electric Exhibition at Paris, but owing to his being unable to find any one who would undertake its construction in the brief time which was allowed him before the final date for sending in applications for space, he was compelled to make public a description only. We give below, from *The Electrician*, a translation of this description from the original French, together with a diagram illustrating the principle of the apparatus.

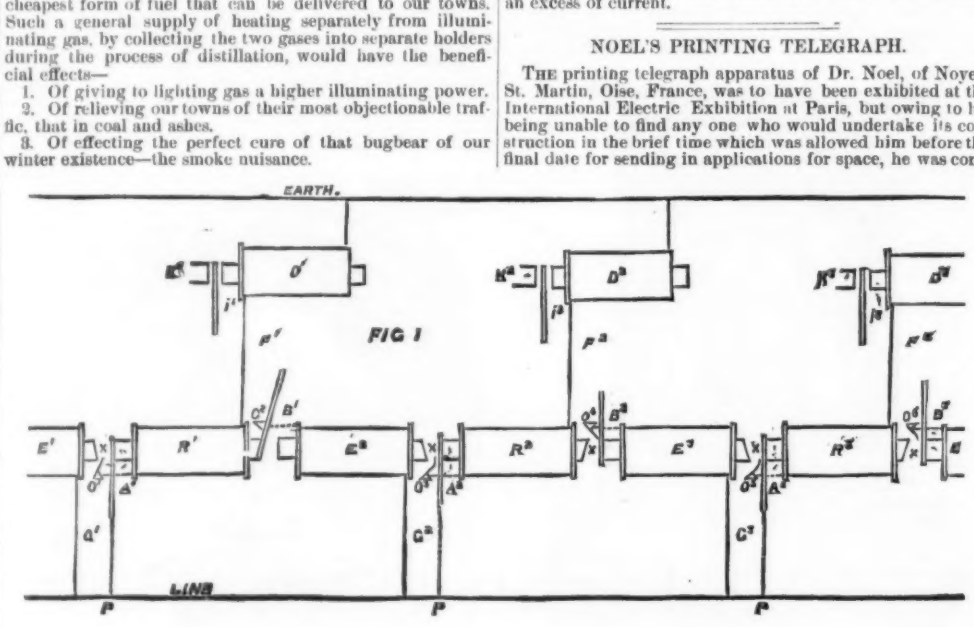


FIG 2

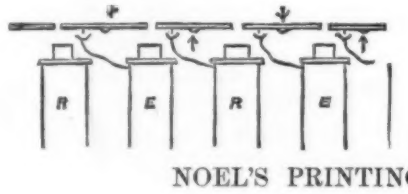


FIG 3

NOEL'S PRINTING TELEGRAPH.

My apparatus, says Dr. Noel, constitutes a multiple and duplex printing telegraph, of which the distributer is based upon a principle altogether different from that of Meyer and of Baudot. Its object is to obtain from a telegraph line the maximum duty it is physically capable of affording. It can be adapted to the systems actually in use, such as that of Morse, of Wheatstone (rapid transmission), of Meyer, of Baudot, etc. In this case it would augment the duty more than ten times.

It is composed of as many sets of ten electro-magnets as there are operators, and the possible number of these is, I venture to say, almost unlimited. These electro magnets are of very small dimensions, with comparatively large wire, so as to allow of those rapid magnetizations which, as M. Marcel Deprez has shown, may readily amount to from five to six hundred per *minute** and may even reach a much higher figure, since this skillful electrician obtained the prodigious number of 3,200 signals in the same space of time by reducing to half a thousandth of a second the period of magnetization of his electro-magnets. I have no need to reach this extreme limit, but can stop at 500 magnetizations per second, giving, if I can utilize them properly, a duty of from 100 to 120 letters per second—say, two messages of 10 words in the same space of time, or 120 per minute, or 7,200 per hour.

It would be impossible to utilize this considerable number of currents with a single electro-magnet at each station; but, by dividing them among the total number of magnets in all the series, in such manner as to transmit only one at a time through each magnet, I am able to utilize each and all successively.

Since at least five currents are requisite for printing a letter, and the apparatus is arranged for duplex transmission,

* Evidently this should be "second."—Translator.

it follows that each operator must have at his disposal five electro magnets—five for transmission and the same number for reception. These magnets are alternately arranged, from the first to the last series, so that a transmission current succeeds a reception current, and so that all the particular series constitute one general series.

The currents can pass to the magnet coil only through the armatures themselves, A B, Fig. 1. The armatures, A, communicate directly with the line at P. The armatures, B, each communicate with a key of a key-board which is under the hand of the operator. The depression of this key places the armature in connection with the positive, and its return with the negative poles of the battery. To the left of each armature is a metallic contact-piece, O, which, however, is not of iron. To each of these contact pieces is soldered the wire from the right hand coil of the magnet.

Each armature successively performs two movements, the first to the left, the second to the right, and the movement to the left is simultaneous with the movement to the right of the neighboring armature to the left, while the movement to the right is simultaneous with the movement to the left of the neighboring armature to the right. These simultaneous movements break the circuit when the movement to the left occurs, and close it when contact is made to the right—that is, break the current on one side and at the same time establish it on the other side.

The arrangement of the armatures in Fig. 1 indicates that a current has just been sent to line from the transmission station through the coil, E_1, and the wire, G_1. Its passage through the coil had attracted the armature, A_1, to its contact-piece, O; but immediately this allowed the current of the receiving station, by means of this contact, to pass also through the armature, A_1, and its contact-piece to the coil, R_1, and thence to pass to earth by the wire, F_1, the relay, D_1, and the earth-wire. The moment its effect—that is, the magnetization of the coil, R_1—has been produced, the current cuts its own passage through O by the attraction of the armature, which has now left O to come into contact with the soft iron core of R_1; and by the same action it opens a path for a transmission current, through B_1, O^2, the coil, E^2, the wire, G^2, and the line-wire. The current which is about to pass through E^2, while it will cut its own path at O^2, will open a path at O^2, by the attraction of A^2, for a fresh reception current, which, passing through R^2, renews the action of the armatures and the production of the same effects.

The duration of each current comprises the period of magnetization necessary to produce the attraction of the armature, and the period occupied by the latter in moving into contact. Between each current there is a period of rest, during which no current passes; this is the time occupied by the two armatures in passing from one to the other contact.

If the movements of these two armatures were not simultaneous—if A_1, for instance, had not broken contact when B_1 makes contact, the working of the apparatus might be faulty, for then the current which passes by B_1, the coil, E^2, and the wire, G^2, might, instead of passing through the line-wire to the other station, again pass by the armature, A_1, its contact piece, O_1, the coil, R_1, the wire, F_1, and the relay, D_1, and thence to the battery through earth.

It is in order to obviate this danger—which is more imaginary than real—that the contacts, O, are not made of iron, so that the armatures may not be retained by the effect of residual magnetism. For the same reason the armatures make contact on the right hand with the soft iron of the electro-magnets, since on this side I have no fear of the effect of residual magnetism, but, on the contrary, endeavor to obtain it, in order that, if the movement of the armature should not be simultaneous, the armature on the left hand may become detached from its contact a thousandth of a second sooner than the armature on the right. By this plan the currents cannot in any case work back and take the wrong path.

Another defect in the apparatus might arise from the failure of a contact, leading to a break-down of all the transmissions, since the magnets all form part of one system. This would be a serious defect; but it is readily avoided, either by the adoption of friction-contacts, or of contacts established by means of mercury. On the former plan, a spring, attached to the contact-piece, O_1, would be placed as shown at O_1 X. But in this case the armatures themselves should be flexible and attached at one of their extremities, so as to give them an elasticity which might have the same effect as the residual magnetism of the electro-magnets—that is, to promote the movement from left to right, and to retard that from right to left. This greater tendency to the right than to the left would be the more necessary, since the addition of the spring, O X, would prolong the contact to the left. If, on the other hand, mercurial contacts were adopted, the magnets would be placed upright, as shown in Fig. 2. This arrangement is the one I first adopted in my apparatus, and the one which was shown at the Palais de l'Industrie. It offers the advantage of dispensing with the separate relays, D_1 D^2 D^3, the electro-magnets of which are replaced by the lower and inactive poles of the receiving magnets, to which a polarized armature is attached—so that the magnets in question take the part both of distributers and of relays.

Nevertheless, I prefer the horizontal arrangement shown in Fig. 1, because in this case the armature is more actively attracted, being influenced at the same time by two forces, viz., that of the magnetism directly produced in one electro magnet and that of the magnetism developed by induction in the adjacent electro-magnet, which repels the armature.

The relays, whether separate from the reception electro-magnets or otherwise, are intended to direct a local current—the printing current—into a *combinateur* on the Baudot system, but simplified, since it is disencumbered from the mechanism intended to establish and to maintain synchronism. My "combiner" further differs from that of Baudot in having 32 contacts instead of 31, the 32d serving for the passage of a negative current during the period of repose, or that in which the keys of the corresponding key-board are all raised. It differs from it, moreover, in being vertical instead of horizontal, and that it turns while the brushes (*balais*) remain at rest. These latter are all five arranged vertically; the type-wheel is fixed in the axis of the "combiner," and turns with it. The printing current consequently can only pass when the contacts corresponding to the letter to be printed pass beneath the brushes. At the same moment the letter is opposite the paper band.

But it is necessary that the printing current should be broken as soon as it has produced its effect, as otherwise errors would be certain to occur. Because, since I do not obtain synchronism, I cause my combiner to make rather more than one rotation in the period necessary for the electricity to return to its starting point after having traversed all the series of all the operators; for instance, four turns per second, if in the same period the operators transmit three sets of currents corresponding to three letters of their dispatch.

Fig. 3 shows the device which I employ to cut off all access of the printing current to the combiner when its presence could only be a disadvantage. The wire of the fifth coil of the receptor, after traversing its relay and before passing to earth, returns to the coil, P, and magnetizes its core. This magnetization attracts the rod, A B, of which the foot, B, is of iron; and this movement releases the spring, C D, which comes into contact with O. It is through this spring and this contact that the printing current passes to enter the combiner; this entrance, therefore, occurs only at the moment when the movement of the polarized armatures has determined the path of the current; and as soon as it can make its exit by the friction contact brushes, that is, only when the contacts corresponding to the letter to be printed are in the vertical line, the printing motion takes place. The hook, E, is connected to the armature of the printing magnet and is raised by the attraction of this armature. It raises at the same time the spring, G D, and by this action breaks the printing current.

DR. CREVAUX.

STILL another name to be added to the long list of martyrs to exploration; still another hero of science, whose memory we have to venerate.

Dr. Crevaux belonged to that great race of courageous and devoted men who seem to be born for sacrifice. A Lorrainian on his mother's side, and a Breton on that of his grandfather, he saw the light at Lorquin, April 1, 1847. He was only thirty-five years of age, then, when he was assassinated by the Tapeti Indians during his last voyage to tropical America. One of his most faithful friends and traveling companions, Mr. E. Lejanne, has just published a few pages in the *Tour du Monde* in regard to unfortunate Crevaux, and from that excellent notice we borrow a few characteristic details which show what the man was that France has just lost.

After having successfully passed his baccalaureate examinations, Crevaux studied for a year at the Faculté de Médecine, at Strassburg, and then went to continue his studies at the Ecole de Médecine Navale, at Brest. What attracted him to this school was a desire to visit regions little known,

DR. CREVAUX, THE SOUTH AMERICAN EXPLORER.

the certainty of traveling over the world, in a word, a wish to incur the perils of the sailor's life; for he loved danger, and it may be said that this was his element.

Crevaux was a small, thick-set man of uncommon vigor, and possessed a high forehead and sparkling eyes. He was a questioner rather than a talker, and would be recognized as a man who was eager to know. He was highly endowed with sagacity. If the theories that he advanced were not always true, they were at least seductive by reason of their ingenuity. He was an excellent companion, indulgent to all, and devoted to his friends. "I do not believe," says Mr. Lejanne, "that he ever refused to do any one a favor."

On the 24th of October, 1868, he was appointed assistant surgeon, a rank corresponding to that of midshipman of the first class. He made his first voyage on the transport Ceres, and visited the French colonies of Senegal and of the Antilles. On board this vessel he had a chance to observe a case of chylous hæmaturia, which was the starting point for his thesis for a doctor's degree.

When the war of 1870 broke out, Crevaux, animated by ardent patriotism, obtained a position in the fourth battalion of Cherbourg marines. At the fight of Freteval this battalion was decimated, its commander was killed, and its surgeon was made prisoner while caring for the wounded. Crevaux succeeded in escaping, and betook himself to Bourges, where he put himself at the disposal of the Minister of War. The latter confided various missions to him, such as carrying several orders, first into Orleans and then into Salins, which was invested by the enemy. Wounded at Chaffois, January 24, 1871, he went to take his post again in the battalion of marines, and left it only in April to go to Brest again. In October, 1873, he was named Surgeon of the Second Class, a grade corresponding to that of midshipman or lieutenant. On the Lamothe Piquet he made a cruise in the South Atlantic, and reached La Plata. In 1876 he gained in a competition his third place. For a long time he had been turning his thoughts toward Guiana, for he knew that for two hundred years numerous travelers had been vainly attempting to reach the Tumuc-Humac mountains, where was supposed to be located that famous El Dorado whose waters detached the golden particles so coveted by miners. Why should he not be able to accomplish what others had not succeeded in doing before him? None had had more enthusiasm—more of the sacred fire—than he. He was young and full of vigor, and all conditions were favorable for him. What more was necessary? A little money. The colony came to his aid. He was about starting on his journey, when the yellow fever broke out in the Salut Islands, and rendered his presence indispensable. His devotion to his patients and his coolness in the presence of the scourge gained him the cross of the Legion of Honor. He was one of the last to undergo an attack of the disease. As soon as he was well he took up his projects again, and ascended the Maroni as far as the country of the Bonis, where he had the good fortune to meet the negro Apatou, who became his constant and devoted companion. The two reached the Tumuc-Humac mountains and descended the Yari as far as the Amazons. This voyage was one of the finest that had been made for a long time. It presented so many difficulties that many old inhabitants of Guiana refused at first to believe that it had been successfully accomplished.

Crevaux did not remain idle long, but ascended the Oyapock again, and descended the Payou as far as the Amazons. After this he made a new voyage, gained the sources of the Yapoura, and descended this river, which had before that been unexplored. He ran great dangers during this voyage, and on his return to France the Geographical Society awarded him its large gold medal. After a new voyage on the Orinoco, Crevaux became desirous of continuing his explorations of tropical America, of reascending the Paraguay, and of descending to the Amazons by the Tupajos and the Xingu. This new exploration was destined to make of him another martyr to geography.

From the report addressed to the Paris Geographical Society by the Argentine Geographical Institute, we are enabled to give some accurate data as to this last voyage of the unfortunate explorer.

Once in Bolivia, Crevaux proceeded to the confluence of the rivers Pilaya and Pilcomayo, where there are some missions of the Franciscan Fathers dependent upon the monastery of Salta, the capital of one of the Argentine provinces. Having reached the regions in the vicinity of the sources of the Pilcomayo, our explorer superintended the construction of three boats, in which the members of the expedition afterward embarked. The number of persons composing the expedition was increased by the addition of a few Bolivian Indians, making in all nineteen men, each armed and provided with three hundred ball cartridges.

Explorations of the Chaco are always dangerous because of the Indians, who, to the number of forty or fifty thousand, as is supposed, people this immense and almost unknown region. However, on the 15th of April, the expedition got under way and descended the river, animated with the intrepidity that characterized its chief to so high a degree, and full of the most sanguine hopes. On the 24th, at six o'clock in the evening, it reached the region of the Teyo, and was received by the Indians with demonstrations of friendship. Here Dr. Crevaux desired to explore an unknown river that had been described by Mr. Sola, the intrepid explorer of the Chaco. It appears that the travelers landed, on the 24th of April, on the shores of the Tapeti Indians, who invited them with friendly demonstrations and afterward basely assassinated them at nightfall. Only two persons were saved, and these were the missionary Ceballos and the Argentine sailor Blanco, who remained in captivity. The government of the Republic and the Argentine Geographical Institute have been engaged ever since in organizing an expedition to go in quest of the remains of the Crevaux mission.—*La Nature.*

OXYGEN FROM THE AIR.

AIR containing 75 per cent. oxygen is obtained by pumping air into a cylinder containing a mixture of 80 parts water and 20 parts glycerine; when the pressure has reached 10 atmospheres, communication is made between the first cylinder and another from which air has been removed; air rich in nitrogen remains in the first cylinder. By repeating this operation, a mixture of 75 per cent. oxygen and 25 per cent. nitrogen can be obtained. Another method of obtaining nearly pure oxygen from air consists in passing the latter into an iron cylinder containing a bag of silk covered with caoutchouc; the dialyzed air is then driven by a steam jet into a condenser, and thence passes into a second similar cylinder; this process is repeated several times; a mixture of 98 per cent. oxygen and 3 per cent. nitrogen may thus be obtained, but for most metallurgical or lighting purposes a mixture containing 60 per cent. oxygen is sufficient. Nitrogen escapes from each iron cylinder by a side tube which dips under water. The silk bags used for dialyzing air are prepared by washing ordinary caoutchouc with a mixture of carbon disulphide and alcohol (whereby substances are removed which would readily stop the pores of the caoutchouc-covered silk, making into a paste with benzine, and placing a layer of this between two layers of silk.

WATER GAS AS FUEL.

PROF. VON MARX, of Stuttgart, delivered a lecture on this subject before the Wurtemberg Society of Engineers, from which the *Deutsche Industrie Zeitung* makes the following abstract:

The success that has attended the introduction of generator gas as fuel in many branches of industry during the past ten years makes it seem desirable that where heat is employed in a small way gas, with its numerous advantages, might come into use. For small fires, as in domestic operations, heating with gas that is conveyed in pipes promises special advantages, if we consider the trouble of getting and preparing ordinary fuel, the difficulty of lighting it, etc., and when we recollect that domestic fires do not utilize more than *ten per cent.*, on an average, of the total heat which the fuel burned is capable of producing, while it is estimated that in gas heating over 80 per cent. is utilized. A cheap fuel gas would have great importance for the small industries, because gas motors can be utilized where very little power is required, while a steam engine presupposes a large business. People are becoming more and more convinced of the advantages of gas heating for every day uses, as shown by the fact that illuminating gas is more and more employed as fuel for heating rooms, for cooking, and for driving gas engines in small trades.

A gas that can be used for heating only can be made considerably cheaper than illuminating gas, since fuel gas can be made from the poorest fuel, while the choice of material to be made into illuminating gas is a very limited one. The proposition that Siemens made twenty years ago, to supply cities not only with illuminating gas but with fuel gas in a separate system of pipes, was not carried into effect simply because such pipes require a large outlay of capital; for it is well known that in city gas works the piping of the city takes by far the larger portion of the first outlay of capital. Since illuminating gas as such has become a necessity, and since it can serve very well for heating purposes, in recent times; when the importance of gas heating began to be recognized, it was questionable whether a special plant

for fuel gas would pay. With the development of electric lighting, the relations will change sooner or later.

It is a fact even now that more light is obtained when illuminating gas is used to drive a gas engine which in turn propels a dynamo machine for producing the electric light than when the gas is used directly for illumination. The following table of A. Niaudet exhibits the results obtained by different experimenters in measuring the light that one horse-power (75 kilogrammeters) will yield with the most important systems of electric lighting. The results are given in carcel units:

1. Voltaic arc, distance of carbons 10 cm. (4 inches), maximum numbers not to be reached in practice. Ordinary Gramme machine (Fontaine)	285
2. Voltaic arc, distance 3 cm. (1¼ inches), ordinary running, Gramme machine (Fontaine)	230
3. Voltaic arc; number given by the president of the committee on lighting by electricity was 2,400 candles; 9·6 candles = 1 carcel	250
4. Jablochkoff candle; Gramme machine with alternate current; one candle requires ⅔ of a horse-power (Honoré), and gives, according to Joubert, 41 carcels, so that each horse-power equals	49·2
5. Edison's incandescent lamp gives, according to Rowland and Barker	11 to 21
According to Bracket and Young	19
6. Swan's incandescent lamp gives 150 candles; 9 candles = 1 carcel.	16⅔

A gas motor using illuminating gas consumes, on the average about one cubic meter (37 cu. ft.) per horse power of 75 kilogrammeters (or 542 foot-pounds). On the other hand, an Argand burner consuming 150 liters (5¼ cu. ft.) of gas per hour gives a light equal to 18 candles, and a cubic meter of gas will give a light equal to 120 candles; and, reckoning a carcel burner equivalent to 9 candles, this corresponds to 13⅓ Carcels. The numbers in the above table are nearly all larger than this, and more especially those with the electric arc, but even the incandescent lamps can compete with gas. In burning illuminating gas, a comparatively large portion of the chemical energy is converted into heat and a small portion into light. With the electric light, the conditions are far more favorable to the production of light.

If the electric light is already cheaper than gas light for lighting large places for equal intensity of light, it may be assumed that, owing to the great attention now paid to the subject, it is highly probable that this will soon be the case for small lights too. Illuminating gas will then be superseded, but fuel gas will gain all the more in importance.

If it be asked how a cheap fuel gas can be made, we come to the conclusion that we must follow some other method than that used in making illuminating gas, because only a small part of the fuel is converted into gas by dry distillation. From 100 kilos of gas coal we get about 28 cubic meters of gas, or 14·4 per cent. by weight, with 66 per cent. of coke, of which 20 per cent. is used in heating the retorts, so that over 40 kilos of solid fuel must be sold or disposed of. A process that converts the fuel all into gas is preferable to dry distillation. Propositions for making fuel gas by dry distillation are not lacking; for example, it has been proposed to distill brown coal in the Furstenwald, 24 miles from Berlin, and convey the fuel gas in pipes of boiler-iron exposed to the air, and pass it into 12 gasometers in the city, from which it can be distributed to consumers like illuminating gas. Fuel can be all converted into gas by *incomplete combustion*, such as takes place in the generators in large heating operations; there the carbon of the fuel is converted into carbonic oxide by the oxygen of the air, and this combustible gas is burned to carbonic acid for heating purposes in the heating apparatus. Of the 8,080 heat units which carbon generates by complete combustion, 2,473 are developed in burning it to carbonic oxide, *i. e.*, 30·6 per cent. of the total heat is lost when "current" gas (gas made at a distance and passed through pipes) is used. Then, again, generator gas is rich in nitrogen, which takes no part in the combustion, but helps to cool the flame; in generator gas, there is, on an average, 70 per cent. by volume of nitrogen, and by theory, if for simplicity one reckon only the carbon, about 66 per cent. It would not pay to carry gas, two-thirds of which was entirely worthless, through a costly system of pipes. Hence it will never do to think of passing generator gas through pipes.

All the conditions are more favorable for water gas. This gas, as is well known, is made by decomposing water by passing its vapor over glowing coal; every form of carbon can be used, charcoal as well as coke. The carbon takes the oxygen away from the water and sets free the hydrogen. The decomposition of water by glowing coal can take place in two ways; either carbonic oxide or carbonic acid may be produced along with hydrogen. The first takes place when there is an excess of carbon and a high temperature; if the temperature falls, carbonic acid is formed. At about 600° C. (1,112° Fahr.), the carbon begins to decompose the water. In practice both processes go on together; a water gas cannot be made that is free from carbonic acid, but in making fuel gas the problem will be to conduct the process in such a manner that only hydrogen and carbonic oxide shall be formed, if possible, in equal portions. In reality, water gas always contains more or less carbonic acid as well as atmospheric oxygen and nitrogen. Theoretically, it takes 1·4 kilos (3 lb.) of carbon to make 3·72 cubic meters (137·6 cu. ft.) of water gas, or every pound of carbon should yield theoretically 44½ cubic feet of gas. The actual yield is considerably less; in experiments made with Strong's system in Stockholm, 1 lb. of coke made 20·6 cu. ft. of gas, or, as the coke left 20 per cent. of ash and dust a pound of carbon made 25·7 cu. ft. of gas, which is 58 per cent. of the calculated theoretical quantity. This small yield is to be ascribed chiefly to the considerable quantity of heat lost in the process, whereby the consumption of fuel coal is much greater than it should be by theory.

If it is asked in how far the manufacture of water gas is justified, we must first remember that, theoretically, nothing is gained and nothing lost in the water gas process. The same quantity of air is requisite to burn the carbon as to burn the water gas made from it. The process only serves to convert solid fuel into gaseous fuel, because in general greater useful effects are obtained by burning the gas than by burning the solid fuel. On the whole, heat is lost, because the water used in the process must be heated to the temperature of the gases escaping from the chimney, whereby the very considerable specific heat and latent heat of the water comes into consideration. From this it follows that in large heating arrangements a special generator that can be placed near the space to be heated will be better than a water gas furnace; that even the simultaneous admission of steam into the generator must have a bad effect, for in that case none of the heat produced in the generator would be lost if the generator gas entered the heating space directly and had no opportunity to lose its heat. The case would be quite different if the gases produced in the generator could be cooled before they entered the heating space; in that case it would be advantageous to make use of part of the heat developed in the generators for making water gas, which could then reproduce in the space to be heated the greater part of the heat taken up in the generator, *i. e.*, in this case it would be expedient to feed the generator with a mixture of steam and air, so as to produce a mixture of water gas and generator gas.

Water gas offers a decided advantage over generator gas, as a fuel gas that has to be conveyed any distance, if we consider the cost of piping. It remains, then, to make the pipe system do the utmost possible service; the greater the heating power of the gas, the better this is accomplished. The heating power of water gas is calculated to be about four times that of generator gas; hence the latter must be left out of account as a "current" or flowing fuel gas, for it will not do to convey the 70 per cent. of inactive nitrogen in generator gas through a costly system of pipes. All that has been said in favor of water gas as compared with generator gas can also be said in favor of ordinary illuminating gas as compared with water-gas, since the former has nearly double the heating power of the latter. Hence the cost of making water gas must remain considerably less than half that of coal gas, if it is to compete with the latter as a fuel. This is, however, possible, because the very poorest fuel can be used for making water gas, and all the material is converted into gas and in a manner requiring much less labor, and with much cheaper and more efficient apparatus than for coal gas. Perhaps it would pay even now to set up water gas generators (gasogens) by the side of the retort benches, so as to make carbureted water gas, which can be made as luminous as the best coal gas and then could be mixed with it.

To see what one water gas generator is capable of doing, we must consider that a coal gas retort may be assumed to make 150 cubic meters (5,550 cu. ft.) in 24 hours, and in the experiments made in Frankfort with a water gas furnace 2,500 cubic meters (92,500 cu. ft.) of water gas were made daily, so that its production corresponds to that of 17 retorts. According to Quaglio, such generators can fill the place of as much as 60 retorts, and the greater their production the cheaper they work.

If water gas can be made cheaply enough, of which there can scarcely be any doubt, and if the future gas lighting is to yield to electric lighting, still illuminating gas will not be entirely dispensed with. Then the fuel gas could be carbureted with petroleum naphtha in suitable carbureters by the consumers themselves, and thus converted into an illuminating gas on their own premises.

Owing to the large percentage of carbonic oxide that it contains, water gas is very poisonous, and so is common illuminating gas. The latter, however, has the very valuable property of smelling so strongly that one part in ten thousand of air can be recognized by the odor; water gas, on the contrary, has scarcely any smell. The proposition that has been made to remove this objection by mixing some strong smelling vapors with the water gas would not present any very great practical difficulty.

From the foregoing it will be seen that under certain circumstances water gas has its legitimate uses, and hence it has a future. In a limited sense it can be justly designated as the "fuel of the future."

[It is hardly fair to compare the amount of water gas made by a gasogen with the quantity of coal gas made in a single retort. A whole bench of retorts does not occupy so much space as one gasogen nor cost so much. It is very much like comparing the relative strength of a locomotive and a mule. A gasogen can be made to produce half a million cubic feet in twenty four hours.

Regarding the lack of smell in fuel gas made from water (so called "hydrogen"), we know that it contains enough sulphureted hydrogen to make its presence known, not only to the nose but by its action on lead paper. This is one of the objections urged, that, owing to the sulphur in it, an unpleasant odor of sulphurous acid is produced where it is burned. Even if this objection that it has no smell held good, it would only be necessary to mix with it a very little of the carbureted gas, such as is sold in this city, and is distinguished for its powerful odor, in order to make it perfectly safe.—ED.]

A DOUBLE MONSTER.

THE accompanying engravings, reproduced from photographs, represent a curious example of teratology described in a recent number of *La Nature* by M. Paul Bert.

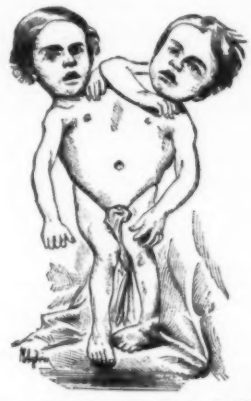


FIG. 1.—A LIVING DOUBLE MONSTER.

M. Bert says: "The monster has, as shown by the photographs, two heads, four arms, two thoraces, one abdomen, one pelvis, and two lower members; in other words, it is double above the umbilicus, and simple below. The fusion of the two bodies begins at the sixth rib. A direct examination, and what is known of similar monsters already observed, permit the assertion to be made that the internal organs are double up to that part of the intestine that corresponds to the region where the umbilical vesicle is inserted in the fœtus. There are, then, four lungs, two hearts, and two stomachs, and the small intestine is double at its beginning, but simple in its greater part. Beyond, all becomes simple in the abdominal and pelvic viscera, as in external appearance. Appearance is the correct word, since in reality there are two absolutely distinct individuals. Above, this is very clear; and below, proof of it is found, aside from anatomical considerations, in the fact that the right leg obeys only the individual to the right, who alone feels pain when it is pinched. Just so the sensitiveness of each half of the body is exclusively connected with the head on the same side.

DOUBLE MONSTER.—(NOW LIVING AND AGED FIVE YEARS.)

"These two individuals, which were born near Turin in 1877, were baptised under the names of John (the one to the right) and James. They are equally developed from an intellectual point of view as well as from a physical (save that James is slightly club-footed), and they resemble each other greatly. Their intelligence is normal; they answer the questions of visitors in French, Italian, and German. They appear to be gentle and loving, although spoiled children, and are continually playing with each other while lying on cushions or seated on the knees of the person who calls himself their father. I am told that they have never been sick. It has been proved by observations made on

other double monsters that one of them may have an inflammatory fever while the other remains well. But that could evidently not occur with regard to an infectious disease. I forgot to ask for information as to their vaccination. The poisoning of one of the individuals would certainly act upon the other.

"This double monster belongs to the genus *Xiphodymus* in the nomenclature of Isidore Geoffroy Saint Hilaire. Bibliographic research will reveal to us quite a number of cases of xiphodymous men and animals. But a small number of these have lived, however. I have read of such a case in Saint Augustine, in 'La Cité de Dieu,' I believe.

"All anatomists have read the description and history of Ritta Christina by Serres. She was a monster analogous to our John-James, but who died toward the age of two years. Her skeleton is in the collection of the Museum of Paris. I know not where I have read the curious, romantic, and lamentable story of the jester of James IV. (?) of Scotland, who belonged to the same teratological genus. One of the component individuals was handsome, intelligent, and musical, while the other, who was ugly, coarse, and a drunkard, killed his brother by killing himself, bottle in hand."

UNDERGROUND TEMPERATURE.

THE Underground Temperature Committee of the British Association have presented a summary (drawn up by Professor Everett) of the results contained in all their reports (fifteen in number) up to the present date, of which the following is an abridgment:

The results are classified under the heads: A. Instruments. B. Methods of observation. C. Questions affecting correctness of observations. D. Questions affecting deductions from observations. E. Comparison of results. F. Mean rate of increase of temperature with depth, and mean upward flow of heat.

A. *Instruments.*—Under this head, we have: 1. Instruments for observing temperature. 2. Subsidiary apparatus.

1. The thermometers which the committee have employed have been of two kinds—slow-action thermometers and maximum thermometers. The present pattern of slow-action thermometer consists of a thermometer having its bulb surrounded by stearine or tallow, the whole instrument being hermetically sealed with a glass jacket, and had its origin in a conference between the secretary and Dr. Stapff in the St. Gothard Tunnel.

Our present patterns of maximum thermometer are two—the Phillips, and the inverted Negretti—both being hermetically sealed in strong glass jackets to prevent the bulbs from receiving pressure when lowered to a great depth in water.

Both instruments are used in a vertical position, and they register truly in spite of jolts in hauling up.

References to Becquerel's thermo-electric method of observing underground temperature were made in three of the reports, and some laboratory experiments were subsequently carried out by the secretary, which led to the conclusion that the method could not be relied on to yield sufficiently accurate results. It may be mentioned that Becquerel's observations are only carried to the depth of 100 feet, whereas we require observations at the depth of 1,000 or 2,000 feet.

2. Under the head of subsidiary (that is non-thermometric) apparatus, plugs for preventing convection-current in a bore or well are referred to. Professor Lebour's umbrella-like plug, in its final form, appears to be very convenient, as it requires only one wire. It remains collapsed so long as the wire is taut, but opens out and plugs the hole when it becomes slack.

B. *Methods of Observation.*—These have chiefly been of two kinds: 1. Observations in holes bored to the depth of a few feet in newly opened rock, either in the workings of a mine or a tunnel, or in a shaft during the sinking. The rock should not have been exposed for more than a week when the hole is bored, and a day may be allowed to elapse for the heat generated by boring to escape before the thermometer is inserted. Very complete plugging is necessary to exclude the influence of the external air. It is desirable to use about two feet of plugging, of which the outer part should be made air tight with plastic clay or greased rag. After the lapse of a few days, the thermometer is to be drawn out by means of a string attached to the handle of its copper case, and the reading taken. The slow-action thermometer above described is employed for this purpose, and there is time to read it with sufficient deliberation before any appreciable change occurs in its indication. It is recommended that the thermometer be then reinserted and plugged as before, and a second reading taken after the lapse of a week. The majority of our successful observations have been made by this method.

2. Observations in deep bores of small diameter. The first report contained a successful application of this method to a bore about 350 feet deep, near Glasgow, which gave very regular results in a series of observations at every sixtieth foot of depth; but in the majority of instances in which it has since been applied, there have been marked irregularities, due apparently to the influx of water from springs at particular points. One of the most valuable of our results was obtained by the application of the method to a bore 863 feet deep, executed at the bottom of a coal mine 1,066 feet deep, giving a total depth of 1,929 feet. The bore in this case was dry at the time of its execution, though full of water at the time of the observation. It was in South Hetton Colliery, Durham. The instrument generally employed in the observations of this class was a maximum thermometer of either the Phillips or the inverted Negretti construction.

The larger the diameter of the bore, the more uncertain does this mode of observation become. The South Hetton bore had a diameter of 2½ inches. The Kentish-Town well, 1,000 feet deep, in which Mr. Symons' observations were made, had a diameter of 8 inches, and the well 660 meters deep at La Chapelle, in the north of Paris, had a diameter of 4½ feet (V., VI., VII.). The temperatures in this last were proved to be largely affected by convection, the water at the top being too warm, and that at the bottom not warm enough. The observations of Herr Dunker, in the bore at Sperenberg, near Berlin, with a depth of 3,390 feet, and a diameter of 12 inches, proved a similar disturbance, amounting, at the top and bottom, to several degrees. As regards the bottom, the proof consisted in showing that when a thermometer at the bottom was protected by a tight plug from the influence of the water above, its indications were higher by 3° R. (= 6¾° F.) than when this precaution was not employed.

C. *Questions Affecting the Correctness of the Observations made* might theoretically include questions as to the correct working of the instruments employed, and as to the personal reliability of observers; but the latter topic has not come into discussion, and the former has not arisen since our present patterns of instrument came into use. The questions for discussion are thus confined to those which relate to possible differences between the temperature of the point at which the thermometer was placed and the normal temperature at the same depth in its vicinity.

1. The heat generated by the action of the boring tool will vitiate the observation, if sufficient time is not allowed for its escape.

A very full discussion of this subject in connection with the great artesian well at La Chapelle will be found in reports V., VI., and VII., clearly establishing the fact that the temperature at the bottom, both on the third and the sixth day after the cessation of boring operations, was 7¼° F. higher than after the lapse of four months, though the water had been left to itself during this interval. Further evidence showing that the temperature in the lower part of a bore full of water may thus be raised several degrees is furnished by the sub-Wealden bore.

2. The generation of heat by local chemical action is well known to be a powerful disturbing cause when pyrites are present. The observers in the mines of Schemnitz say, "Pyrites and also decaying timber were avoided, as being known to generate heat." The observations in the coal mines of Anzin show a temperature of 70¾° F. in shaft IV. (a very dry one) at the depth of 21·2 meters, or less than 70 feet. This must be about 15° F. above the normal temperature. In shaft II. the observer mentions that there was, at a depth of 90 m., a seam of coal in which heat was generated by oxidation.

At Talargoch lead mine, in Flintshire, the discrepancies between the temperatures at the six observing stations are suggestive of local chemical action.

3. Convection of heat has proved a very troublesome disturbing cause.

As to convection of heat by air in a shaft or well not filled with water, evidence will be found in the second report, both in the case of Mr. Hunter's observations in the shafts of two salt mines at Carrickfergus, having the depths of 570 and 770 feet respectively, and in the case of Mr. Symons' observations at Kentish Town, where the first 210 feet of the well are occupied with air. At the depth of 150 feet the temperature was 52·1 in January, and 54·7 in July.

Convection of heat by water in old shafts which have been allowed to become flooded is very manifest in some of the observations communicated by Mr. Burns in the second and fourth reports. In Allendale shaft (Northumberland), 300 feet deep, with about 150 feet of water, the temperature was practically the same at all depths in the water, and this was also the case in Breckon Hill shaft, where the observations extended from the depth of 42 feet to that of 350 feet. A similar state of things was found in a shaft at Ashburton (Devon) by Mr. Amery, who observed at every fiftieth foot of depth down to 350 feet.

Convection by water in the great well at La Chapelle, 660 m. (2,165 feet) deep, and 1·35 m. (4 feet 5 inches) in diameter at the bottom, appears probable from the following comparisons:

Very concordant observations (communicated by M. Walferdin to *Comptes Rendus* for 1838) at three different wells in the Paris basin, of the respective depths of 263 m., 400 m., and 600 m., show by comparison with one another and with the constant temperature in the artificial caves under the Paris Observatory a rate of increase of 1° F. in 56 or 57 feet. These data would give, at the depth of 100 m., or 328 feet, a temperature of 57°, and at the depth of 660 m., or 2,165 feet, a temperature of 90°; whereas the temperatures actually observed at those depths in the well at La Chapelle in October, 1873, when the water had been undisturbed for a year and four months, were 59·5° and 76°. It thus appears probable that the upper part of the well is warmed, and the lower part cooled, by convection. Further light may be expected to be thrown on this point when the well reaches the springs, and the water spouts above the surface, as it does at the Puits de Grenelle. A letter received by the secretary in July, 1882, states that engineering difficulties have prevented any deepening of the well since the above observations, but that arrangements for this purpose have now been made.

More certain and precise information as to the effect of convection in deep bores is furnished by the experiments of Herr Dunker at Sperenberg. The principal bore at Sperenberg has a depth of 4,052 Rhenish or 4,172 English feet, and is entirely in rock salt, with the exception of the first 283 feet. Observations were first taken (with a maximum thermometer on the overflow principle) at numerous depths, from 100 feet to the bottom, and showed a fairly regular increase of temperature downward. The temperature at 700 feet was 16·08° R., and at 3,390 feet 34·1° R. Plugs were then contrived which could be fixed tight in the bore at any depth with the thermometer between them, or could be fixed above the thermometer for observing at the bottom. Convection was thus prevented, and a difference of one or two degrees Réaumur was found in the temperatures at most of the depths; at 700 feet the temperature was now 17·06° R., and at 3,390 feet 36·15°. We have thus direct evidence that convection had made the temperature at 3,390 feet 2·05° R., or 4·6° F. too low; and this, as Herr Dunker remarks, is an underestimate of the error, inasmuch as convection had been exerting its equalizing action for a long time, and its effect could not be completely destroyed in the comparatively short time that the plugs were in position. Again, as regards the effect of convection on the upper part of the bore, the temperature 11·0° R. was observed at the depth of 100 feet in the principal bore when no plugs were employed, while a second bore only 100 feet deep in its immediate vicinity showed a temperature 9·0° R. at the bottom. This is direct evidence that the water near the top of the great bore had been warmed 2° R., or 4½° F. by convection.

Suggestions for observations in filled-up bores will be found in the eleventh report, but they have not yet taken a practical shape.

D. *Questions Affecting Deductions from Observations.*—1. In many instances, the observations of temperature have been confined to considerable depths, and in order to deduce the mean rate of increase from the surface downward it has been necessary to assume the mean temperature of the surface. To do this correctly is all the more difficult, because there seems to be a sensible difference between the mean temperature of the surface and that of the air a few feet above it.

In the third report some information on this point is given, based on observations of thermometers 22 inches deep at some of the stations of the Scottish Meteorological Society, and of thermometers 3 (French) feet deep at Greenwich and at Edinburgh. These observations point to an excess of surface temperature above air temperature, ranging from half a degree to nearly two degrees, and having an average value of about one degree.

Dr. Schwartz, Professor of Physics in the Imperial School of Mines at Schemnitz, in sending his observations made in the mines at that place, remarks on this point:

"Observations in various localities show that in sandy soils the excess in question amounts, on the average, to about half a degree centigrade. In this locality the surface is a compact rock, which is highly heated by the sun in summer, and is protected from radiation by a covering of snow in winter; and the conformation of the hills in the neighborhood is such as to give protection against the prevailing winds. Hence the excess is probably greater here than in most places, and may fairly be assumed to be double the above average."

Some excellent observations of underground temperature at small depths were made at the Botanic Gardens, Regent's Park, London, for the six years 1871–76, along with observations of air temperature, and have been reduced by Mr. Symons. They are at depths of 3, 6, 12, 24, and 48 inches beneath a surface of grass, and their joint mean derived from readings at 9 A.M. and 9 P.M. for the six years is 49·9, the mean for the 48-inch thermometer being 50·05. The mean air temperature derived in the same way from the readings of the dry bulb thermometer is 49·6. Hence it appears that the excess of soil above air is in this case about 0·4°.

Quetelet's observations for three years at Brussels (p. 48 of his "Mémoire") make the earth, at depths less than 1½ feet, colder than the air, and at greater depths warmer than the air.

Caldecott's observations for three years at Trevandrum, in India, make the ground at the depth of 3 feet warmer than the air by 5·7° F.

Dr. Stapff, in his elaborate publications on the temperature of the St. Gothard tunnel, arrives at the conclusion that the mean temperature of the soil on the surface of the mountain above the tunnel is some degrees higher than that of the air, the excess increasing with the height of the surface and ranging from 2° or 3° C. near the ends of the tunnel to 5° or 6° in the neighborhood of the central ridge.

2. Connected with this is the question whether the mean annual temperature of the soil increases downward from the surface itself, or whether, as is sometimes asserted, the increase only begins where annual range ceases to be sensible—say at a depth of 50 or 60 feet.

The general answer is obvious from the nature of conduction. Starting with the fact that temperature increases downward at depths where the annual range is insensible, it follows that heat is traveling upward, because heat will always pass from a hotter to a colder stratum. This heat must make its way to the surface and escape there. But it could not make its way to the surface unless the mean temperature diminished in approaching the surface; for if two superposed layers had the same mean temperature, just as much heat would pass from the upper to the lower as from the lower to the upper, and there would not be that excess of upward flow which is necessary to carry off the perennial supply from below.

This reasoning is rigorously true if the conductivity at a given depth be independent of the temperature, and be the same all the year round. By "conductivity" we are to understand the "flux of heat" divided by the "temperature gradient," where by the "flux of heat" is meant the quantity of heat which flows in one second across unit area at the depth considered, and by the "temperature gradient" is meant the difference of temperature per foot of descent at the depth and time considered.

Convection of heat by the percolation of water is here to be regarded as included in conduction. If the conductivity as thus defined were the same all the year round, the increase of mean temperature per foot of depth would be independent of the annual range, and would be the same as if this range did not exist.

As a matter of fact, out of six stations at which first-class underground thermometers have been observed, five show an increase downward, and one a decrease. The following are the results obtained for the depths of 3, 12, and 24 French feet:

	3 feet.	12 feet.	24 feet.
Brussels, three years	51·85	53·09	53·71
Edinburgh (Craigleith) five years	45·88	45·92	46·07
Edinburgh (Gardens) five years	46·13	46·76	47·09
" (Observatory) seventeen years	46·27	46·92	47·18
Trevandrum (India) three years,	85·71	86·12	....
Greenwich, fourteen years	50·92	50·61	50·28

In calculating the mean temperature at 12 feet for Trevandrum, we have assumed the temperature of May, which is wanting, to be the same as that of April.

Omitting Trevandrum, and taking the mean values at 3 and 24 French feet, we find an increase of 0·656 of a degree in 21 French feet, which is at the rate of 1° for 32 French or about 34 English feet.

3. Another question which it has sometimes been necessary to discuss is the influence which the form of the surface exerts on the rate of increase of temperature with depth.

The surface itself is not in general isothermal, but its temperature is least where its elevation is greatest; the rate of decrease upward or increase downward being generally estimated at 1° F. for 300 feet. This is only about one-fifth of the average rate of increase downward in the substance of the earth itself beneath a level surface. If the two rates were the same, the isotherms in the interior of a mountain would be horizontal, and the form of the surface would have no influence on the rate of increase of temperature with depth. The two extreme assumptions that the surface is an isotherm, and that the isotherms are horizontal, lie on opposite sides of the truth. The isotherms, where they meet the sides of the mountain, slope in the same direction as the sides of the mountain, but to a less degree. Probably the tangents of the two slopes are generally about as 3 to 4.

Further, if we draw a vertical line cutting two isotherms, the lower one must have less slope than the upper, because the elevations and depressions are smoothed off as the depth increases.

The practical inference is that the distance between the isotherms (in other words, the number of feet for 1° of increase) is greatest under mountain crests and ridges, and is least under bowl-shaped or trough-shaped hollows.

The observations in the Mount Cenis tunnel, and the much more complete observations made by Dr. Stapff in the St. Gothard tunnel, fully bear out these predictions from theory. The discussion of the former occurs in the fourth report, p. 15.

As regards the St. Gothard tunnel, Dr. Stapff reports: "The mean rate of increase downward in the whole length of the tunnel is 0·02068 of a degree Centigrade per meter of depth, measured from the surface directly over. This is 1° F. for 88 feet. Where the surface is a steep ridge, the increase is less rapid than this average; where the surface is a valley or plain, the increase is more rapid."

4. The question whether the rate of increase downward is, upon the whole, the same at all depths, was raised by Prof. Mohr in his comments upon the Sperenberg observations, and is discussed, so far as these observations bear upon it, in the ninth and eleventh reports.

Against the Sperenberg observations, which, upon the whole, show a retardation of the rate of increase as we go deeper, may now be set the Dukinfield observations, begun by Sir William Fairbairn and continued by Mr. Garside. Taking Mr. Garside's observations, and assuming a surface temperature of 49°, the increase in the first 1,987½ feet, is at the rate of 1° in 79·5 feet; in the next 420 feet it is at the rate of 1° in 70 feet; and in the last 383½ feet it is at the rate of 1° in 51⅙ feet.

From a theoretical point of view, in places where there is no local generation of heat by chemical action the case stands thus:

The flow of heat upward must be the same at all depths, and this flow is equal to the rate of increase downward multiplied by the conductivity, using the word "conductivity" (as above explained) in such a sense as to include convection. The rate of increase downward must, therefore, be the same at all depths at which this conductivity is the same.

This reasoning applies to superposed strata at the same place, and assumes them to be sufficiently regular in their arrangement to insure that the flow of heat shall be in parallel lines, not in converging or diverging lines.

5. If we have reason to believe that the flow of heat upward is nearly the same at all places, then the above reasoning can also be applied approximately to the comparison of one place with another—that is to say, the rates of increase downward, in two masses of rock at two different places, must be approximately in the inverse ratio of their conductivities. In the cooling of a heated sphere of heterogeneous composition, the rates of flow would at first be very unequal through different parts of the surface, being most rapid through those portions of the substance which conducted best; but these portions would thus be more rapidly drained of their heat than the other portions, and thus their rates of flow would fall off more rapidly than the rates of flow in the other portions. If the only differences in the material were differences of conductivity, we might on this account expect the outflow to be after a long time nearly the same at all parts of the surface. But when we come to consider differences of "thermal capacity per unit volume," it is clear that with equal values of "diffusivity," that is, of "conductivity divided by thermal capacity of unit volume" in two places, say in two adjacent sectors of the globe, there would be the same distribution of temperatures in both, but not the same flow of heat, this latter being greatest in the sector in which the capacity and conductivity were greatest.

Where we find, as in Mr. Deacon's observations at Bootle, near Liverpool, and to a less marked degree in the observations of Sir William Fairbairn and Mr. Garside, near Manchester, an exceptionally slow rate of increase, without exceptionally good conductivity, it is open to us to fall back on the explanation of exceptionally small thermal capacity per unit volume in the underlying region of the earth, perhaps at depths of from a few miles to a few hundred miles.

6. A question which was brought into consideration by Prof Hull, in connection with the great difference between the rate of increase at Dukinfield and that at Rosebridge, is the effect of the dip of the strata upon the vertical conductional of heat. Laminated rocks conduct heat much better along the planes of lamination than at right angles to them. If k_1 denote the conductivity along, and k_2 the conductivity normal to the planes of lamination, and if these planes are inclined at an angle θ to the horizon, the number of feet per degree of increase downward corresponding to a given rate of outflow through the surface will be the same as if the flow were vertical with a vertical conductivity:

$$k_1 \sin^2\theta + k_2 \cos^2\theta.$$

Prof. Herschel finds about 1·03 as the ratio of the two principal conductivities in Loch Rannoch flagstone, and 1·875 as the ratio in Festiniog slate.

The dip of the strata at Dukinfield is stated by Mr. Garside to be 15°, and we have $\sin^2 15° = 0{\cdot}07$, $\cos^2 15° = 0{\cdot}93$.

If we assume $k_1 = 1{\cdot}3k_2$, as in the case of flagstone, we find for the effective vertical conductivity $k_2(0{\cdot}09 + 0{\cdot}93) = 1{\cdot}02\,k_2$, so that the number of feet per degree would only be increased by 2 per cent.

It is not likely that the two conductivites in the strata at Dukinfield are so unequal as even in the case of flagstone, so that 2 per cent. is a high estimate of the effect of their dip on the vertical rate of increase so far as pure conduction is concerned. The effect of dip in promoting the percolation of water is a distinct consideration, but the workings of the Dukinfield mines are so dry that this action does not seem to be important.*

E. *We now proceed to a comparison of results.*

The localities at which definite results have been obtained may thus be classified:

1. Metallic mines. 2. Coal mines. 3. Wells and wet borings. 4. Tunnels.

1. The mines at Przibram in Bohemia, with a depth of 1,900 feet, are in very quartzose rock, and give a very slow rate of increase, viz., 1° F. in 135 feet. As all the shafts are in lofty hills, an allowance of $\frac{1}{7}$ may be made for convexity, leaving 1° F. in 126 feet. Quartz is found by Prof. Herschel to have a conductivity of about 0·0086.

The mines at Schemnitz in Hungary, with a depth of 1,368 feet, give an average rate of 1° F. in 74 feet, the rock being a green hornblende-andesite (in German, *Grünstein-Trachyt*), which is a compact, fine-grained, crystalline, more or less vitreous rock. Prof. Lebour estimates its conductivity as being probably nearly the same as that of Calton Hill trap-rock, which Prof. Herschel found to be about 0·0029.

2. The principal results from coal mines are as follows:

The mines of the Societe Cocqueril at Seraing (Belgium), with a depth of 1,657 feet, give an average rate of 1° F. in 50 feet. The rock is coal shale. Prof. Herschel found for shale the low conductivity 0·0019.

The mines of Anzin, in the north of France, with a depth of 658 feet, gave in the deepest shaft an increase or 1° in 47 feet.

Rosebridge Colliery, near Wigan, with a depth of 2,445 feet, gave a mean rate of 1° in 54 feet.

The four following are in the East Manchester coalfield:

Astley Pit, Dukinfield, with a depth of 2,700 feet, gave a mean rate of 1° in 72 feet.

Ashton Moss Colliery, with a depth of 2,790 feet, gave 1° in 77 feet.

Bredbury Colliery, with a depth of 1,020 feet, gave 1° in 78·5 feet.

Nook Pit, with a depth of 1,050 feet, gave 1° in 79 feet.

South Hetton Colliery, Durham, with a depth of 1,929 feet, including a bore hole at bottom, gives very consistent observations at various depths, and an average rate of 1° in 57·5 feet.

Boldon Colliery, between Newcastle and Sunderland, with a depth of 1,514 feet, and excellent conditions of observation, gives an average rate of 1° in 49 feet.

Kingswood Colliery, near Bristol, with a depth of 1,769 feet, and remarkable consistency between observations at various points, gives 1° in 68 feet.

Prof. Phillips' observations in Monkwearmouth Colliery, published in *Phil. Mag.* for December, 1834, showed a temperature of 71·2 in a hole bored in the floor of a recently exposed part at the depth of 1,584 feet. The surface of the ground is 87 feet above high water, and the mean temperature of the air is assumed by Prof. Phillips to be 47·6. If, as usual, we add 1° to get the soil temperature, instead of assuming, as Prof. Phillips does, that the temperature 100 feet deep is identical with the air temperature at the surface, we obtain a rate of increase of 1° in 70 feet.

3. The following are the most trustworthy results from wells and borings:

The Sperenberg bore, near Berlin in rock salt, with a depth of 3,492 English feet, to the deepest reliable observation gave an average of 1° in 51·5 feet. This result is entitled to special weight, not only on account of the great depth, but also on account of the powerful means employed to exclude convection.

Rock salt, according to Prof. Herschel, has the very high conductivity 0·0113.

Three artesian wells in the chalk of the Paris basin gave the following results:

	Feet.	Rate, feet.
St. Andre, depth of observation..	880	1° in 56·4
Grenelle	1,312	1° in 56·9
Military School	568	1° in 56·2

An artesian well at St. Petersburg, in the Lower Silurian strata, with a depth of 656 feet, gave about 1° in 44 feet.

A well sunk at Yakoutsk, in Siberia, to the depth of 540 feet, disclosed the fact that the ground was permanently frozen to this depth, and probably to the depth of 700 feet. The rate of increase of temperature was 1° in 52 feet.

Of the English wells in which observations have been taken, the most important is that at Kentish Town, in which Mr. G. J. Symons, F.R.S., has taken observations to the depth of 1,100 feet. The temperatures at different depths form a smooth series, and have been confirmed by observations repeated at long intervals. The only question that can arise as to the accuracy of the results is the possibility of their being affected by convection.

The well is 8 feet in diameter, with brickwork to the depth of 540 feet, and this part of it is traversed by an iron tube 8 inches in diameter, which is continued to the depth of more than 1,300 feet from the surface. The tube is choked with mud to the depth of about 1,080 feet, so that the deepest observations were taken under 20 feet of mud. The temperature at 1,100 feet was 69·9°, and by combining this with the surface temperature of 49·9° observed at the Botanic Gardens, Regent's Park, we obtain a rate of 1° in 55 feet. These data would give at 250 feet a calculated temperature of 54·5, whereas the temperature actually observed at this depth was 56·1, or 1·6° higher; the temperature at 300 feet and at 350 feet being also 56·1. This seems to indicate convection, but it can be accounted for by convection in the 8-foot well which surrounds the tube, and does not imply convection currents within the tube. Convection currents are much more easily formed in water columns of large diameter than in small ones, and the 20 feet of mud at the bottom give some security against convection at the deepest point of observation. It is important to remark that the increase from 1,050 to 1,100 feet is rather less than the average instead of being decidedly greater, as it would be if there were convection above, but not in the mud. The rate of 1° in 55 feet may therefore be adopted as correct.

The strata consist of Tertiary strata, chalk (586 feet thick), upper greensand, and gault.

The Kentish Town temperature at the depth of 400 feet (58°) is confirmed by observations in Mr. Sich's well at Chiswick, which is 395 feet deep, and has a temperature varying from 58° to 57·5°.

The Bootle well, belonging to the Liverpool Waterworks, is 1,302 feet deep, and the observations were taken in it during the sinking. The diameter of the bore is 24 inches, and convection might have been suspected but for the circumstance that there was a gradual upward flow of water from the bottom, which escaped from the upper part of the well by percolation to an underground reservoir near at hand. This would check the tendency to downflow of colder water from the top; and as the observations of temperature were always made at the bottom, they would thus be protected against convective disturbance.

The temperature at 226 feet was 52°, at 750 feet 56°, at 1,302 feet 59°, giving by comparison of the first and last of these a mean rate of 1° in 154 feet. The circumstance that the boring ceased for six weeks at the depth of 1,004 feet, and the temperature fell during this interval from 58·1° to 57·0°, would seem to indicate an elevation of 1° due to the heat generated by the boring tool. An assumed surface temperature of 49° (only 0·9° lower than that of the Botanic Gardens in London) would give by comparison with 57°, at 1,004 feet, a rate of 1° in 125½ feet, and by comparison with 59°, at 1,302 feet, a rate of 1° in 130 feet, which last may be adopted as the best determination. The rock consists of the pebble beds of the Bunter or Lower Trias, and the boring was executed at the rate of nearly 100 feet per month.

The boring at Swinderby, near Scarle (Lincoln), in search of coal, was carried to a depth of 2,000 feet, with a diameter at the lower part of only 3⅛ inches—a circumstance favorable to accuracy, both as impeding convection and as promoting the rapid escape of the heat of boring. The temperature at the bottom was 79°, the water having been undisturbed for a month, and this, by comparison with an assumed surface temperature, of 50°, gives a rate of 1° in 69 feet.

The rocks are Lower Lias, New Red Marl (569 feet thick), New Red Sandstone (790 feet thick), Red Marl, and earthy Limestone.

The following results have been obtained from shallow borings. The first three were made under Sir William Thomson's direction, with a thermometer which could be read by estimation to hundredths of a degree:

Blythswood bore, near Glasgow, with a depth of 347 feet, gave a very regular increase of 1° in 50 feet.

Kirkland Neuk bore, in the immediate vicinity of the above, gave consistent observations at different seasons of the year from 180 feet to the bottom (354 feet), the rate being 1° in 53 feet. This bore passed through coal which had been "very much burned or charred."

South Balgray bore, near Glasgow, and north of the Clyde, with an available depth of 525 feet, gave, by comparing the temperature at the bottom with that at 60 feet, a rate of 1° in 41 feet.

Shale extends continuously from 390 to 450 feet from the surface, and the increase in these 60 feet of shale was 2·92°, which is at the rate of 1° in 30 feet. This rapid increase agrees with the fact that shale has very low conductivity, averaging 0·0019 in Prof. Herschel's experiments.

The only small bore remaining to be mentioned is that at Manegaon, in India, which had 310 feet available, and gave, by comparing the temperature at this depth with that at 60 feet, a rate of 1° in 68 feet. The rocks consist of fine softish sandstones and hard silty clays, the dip being 10°.

4. *Tunnels.*—The Mont Cenis tunnel, which is about seven miles long, is at a depth of exactly a mile (5,280 feet) beneath the crest of Mont Fréjus overhead. This was the warmest part of the tunnel, and had a temperature of 85·1° F. The mean air temperature at the crest overhead was calculated by the engineer of the tunnel, M. Giordano, by interpolating between the known temperature of the hill of San Theodule and that of the city of Turin, the former being 430 meters higher, and the latter 2,650 meters lower, than the point in question. It is thus calculated to be —2·6° C. or 27·3° F. If, according to our usual rule, we assume the ground to be 1° warmer than the air, we have 28·3° to compare with 85·1°. This gives a rate of 1° in 93 feet; but, inasmuch as the convexity of the surface increases the distance between the isotherms, a correction will be necessary before we can fairly compare this result with rates under level ground. As a rough estimate we may take ¾ of 93, and adopt 1° in 70 feet as the corrected result.

"The rocks on which the observations have been made are absolutely the same, geologically and otherwise, from the entrance to the tunnel, on the Italian side, for a distance of nearly 10,000 yards. They are not faulted to any extent, though highly inclined, contorted, and subjected to slight slips and slides. They consist, to a very large extent indeed, of silicates, chiefly of alumina, and the small quantity of lime they contain is a crystalline carbonate."

The St. Gothard tunnel, which has a length of about nine miles, has been subjected to much more minute observation, a skilled geologist, Dr. Stapff, having, under government direction, devoted his whole time to investigating its geology and physics. He not only observed the temperature of the rock in the tunnel at very numerous points, but also determined, by observations of springs, the mean temperatures of the surface of the mountain at various points, and compared these with an empirical formula for air temperature deduced from the known mean temperatures of the air at Göschenen, Andermatt, Airolo, and the Hospice of St. Bernard. He infers from his comparisons a considerable excess of soil above air temperature, increasing from 2° C. at the ends of the tunnel to 6° C. at the crest of the mountain over the center of the tunnel. The highest temperature of the rocks in the tunnel was at this central part, and was about 30·6° C. or 87° F. The soil temperature at the crest above it was about —0·6° C. or 31° F., giving a difference of 56° F. The height of the crest above sea-level was about 2,850 m., and that of the tunnel at this part 1,150 m., giving a difference of 1,700 m. or 5,578 feet. The rate of increase here is, therefore, about 1° F. in 100 feet; and if we apply the same correction for convexity as in the case of the Mont Cenis tunnel, this will be reduced to about 1° F. in 87 feet as the equivalent rate under a level surface. From combining his observations in all parts of the tunnel through the medium of empirical formulæ, Dr. Stapff deduces an average rate of 1° F. for every 88 feet measured from the surface directly overhead. Where the surface is a steep ridge, the increase was less rapid than this average; where the surface was a valley or plain, the increase was more rapid. As this average merely applies to the actual temperatures, the application of a correction for the general convexity of the surface would give a more rapid rate. If we bring the isotherms nearer by one part in 15, which seems a fair assumption, we shall obtain a rate of 1° F. in 82 feet.

Collecting together all the results which appear reliable, and arranging them mainly in the order of their rates of increase, but also with some reference to locality, we have the following list:

		Depth, feet.	Feet for 1° F.
Bootle waterworks (Liverpool)		1,392	130
Przibram mines (Bohemia)		1,900	126
St. Gothard tunnel		5,578	82
Mont Cenis tunnel		5,280	79
Talargoch lead mine (Flint)		1,041	80
Nook Pit, Colliery	East Manchester coalfield.	1,050	79
Bredbury "		1,020	78½
Ashton Moss "		2,790	77
Denton "		1,317	77
Astley Pit, Dukinfield.		2,700	72
Schemnitz mines (Hungary)		1,368	74
Scarle boring (Lincoln)		2,000	69
Manegaon boring (India)		310	68
Pontypridd colliery (S. Wales)		855	76
Kingswood "	(Bristol)	1,769	68
Radstock "	(Bath)	620	62
Paris artesian well, Grenelle		1,312	57
" " "	St. André	880	56
" " "	Military School	568	56
London " "	KentishTown	1,100	55
Rosebridge colliery (Wigan)		2,445	54
Yakoutsk, frozen ground (Siberia)		540	52
Sperenberg, boring in salt (Berlin)		3,492	51½
Seraing collieries (Belgium)		1,657	50
Monkwearmouth collieries (Durham)		1,584	70
South Hetton "	"	1,929	57½
Boldon "	"	1,514	49
Whitehaven "	(Cumberland)	1,250	45
Kirkland Neuk bore (Glasgow)		354	53
Blythswood "	"	347	50
South Balgray "	"	525	41
Anzin collieries (north of France)		658	47
St. Petersburg, well (Russia)		656	44
Carrickfergus, shaft of salt mine (Ireland)		770	43
" " "	"	570	40
Slitt mine, Weardale (Northumberland)		660	34

The depth stated is in each case that of the deepest observation that has been utilized.

F. *In deducing a mean from these very various results,* it is better to operate, not upon the number of feet per degree, but upon its reciprocal—the increase of temperature per foot. Assigning to the results in the foregoing list weights

* Though the workings are dry, there is a large quantity of water in the superincumbent strata.

proportional to the depths, the mean increase of temperature per foot is found to be 0·01563, or about $\frac{1}{64}$ of a degree per foot—that is, 1° F. in 64 feet.

It would be more just to assign greater weight to those single results which represent a large district or an extensive group of mines, especially where the data are known to be very accurate. Doubling the weights above assigned to Przibram, St. Gothard, Mont Cenis, Schemnitz, Kentish Town, Rosebridge, and Seraing, and quadrupling that assigned to Sperenberg, no material difference is made in the result. The mean still comes out 1° F. in 64 feet, or more exactly, 0·01566 of a degree per foot.

This is a slower rate than has been generally assumed, but it has been fairly deduced from the evidence contained in the committee's reports; and there is no reason to throw doubt on the results in the upper portion of the above list more than on those in its lower portion. Any error that can reasonably be attributed to the data used in the calculations for the St. Gothard tunnel and for the numerous deep mines of the East Manchester coalfield, will have only a trifling effect on the rates of increase assigned to these localities.

To obtain an approximation to the rate at which heat escapes annually from the earth, we will first reduce the above rate of increase 0·01566 to centigrade degrees per centimeter of depth. For this purpose we must multiply by 0·0182, giving 0·000285.

To calculate the rate of escape of heat, this must be multiplied by the conductivity.

The most certain determinations yet made of the conductivity of a portion of the earth's substance are those deduced by Sir William Thomson by an indirect method, involving observations of underground thermometers at three stations at Edinburgh, combined with laboratory measurement of the specific heats and densities of the rocks in which the thermometers were planted. The specific heats were determined by Regnault, and the densities by Forbes. Specific heats and densities can be determined with great accuracy in the laboratory, but the direct determination of conductivity in the laboratory is exceedingly difficult, it being almost impossible to avoid sources of error which make the conductivity appear less than it really is.

Prof. Herschel, in conjunction with a committee of the British Association, has made a very extensive and valuable series of direct measurements of the conductivities of a great variety of rocks, and has given additional certainty to his results by selecting as two of the subjects of his experiments the Calton Hill trap and Craigleith sandstone, to which Sir William Thomson's determinations apply.

From combining Prof. Herschel's determinations with those of Sir Wm. Thomson, 0·0058 is adopted as the mean conductivity of the outer crust of the earth, which, being multiplied by the mean rate of increase, 0·000285, gives

$$16{,}330\times10^{-10}$$

as the flow of heat in a second across a square centimeter. Multiplying by the number of seconds in a year, which is approximately 31½ millions, we have

$$1{,}633\times315\times10^{-4}=41{\cdot}4.$$

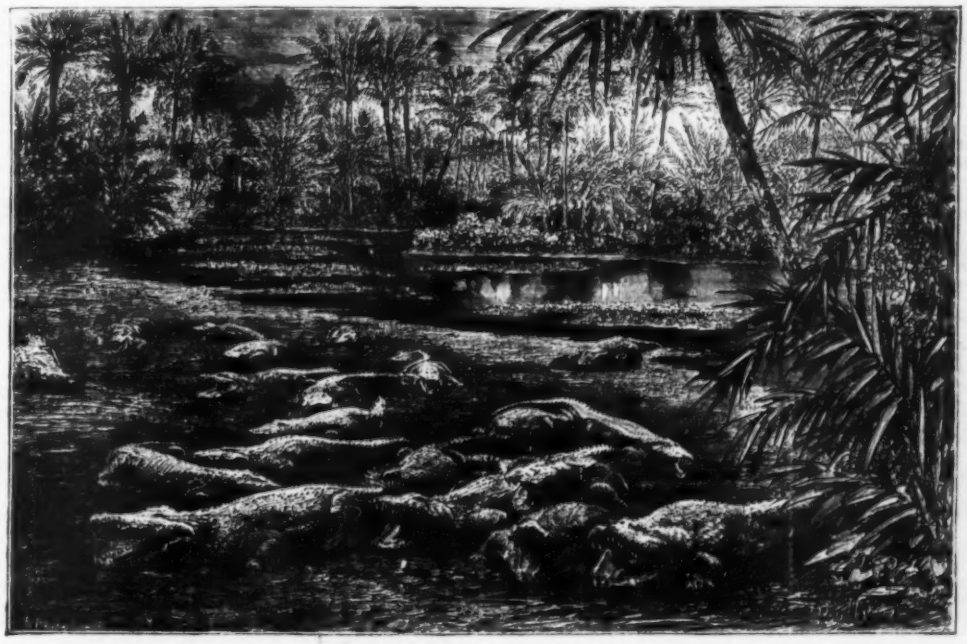
This, then, is our estimate of the average number of gramme degrees of heat that escape annually through each square centimeter of a horizontal section of the earth's substance.

A PHOTOGRAPH OF CROCODILES.

THE photograph which we herewith accurately reproduce in the accompanying engraving is not only an object of considerable curiosity from a natural history standpoint, but also records a somewhat heroic act on the part of him who took it.

An English traveler, in making an exploration in the environs of Bombay, carried with him a photographic apparatus for taking views of landscapes. On passing Muygapier, near Kurrachee, he was struck by the appearance of a magnificent grove of tropical trees bordering a swamp, and stopped to photograph it. He had just fixed the tripod in the ground and put his head under the black cloth to focus the objective, when all at once a large crocodile showed its head above water and proceeded toward the shore. Another succeeded the first, and finally a whole troupe appeared. Another person would have run; but our English photographer stood his ground, and continued his focusing with all the coolness that characterizes his race. He then put the collodionized glass into the apparatus and calmly took the portraits of the reptiles while they lay basking in the sun. When he was through, he put on his hat and left.

We have been enabled to procure a copy of this remarkable photograph in London, and are happy to present our readers with a *facsimile* of it. We have thought it proper to present the original to the Paris Museum of Natural History.—*La Nature.*



CROCODILES PHOTOGRAPHED AT MUYGAPIER, NEAR KURRACHEE, BOMBAY.

JOTTINGS ON ODORS, AND THEIR RECOGNITION.

By J. W. SLATER.

THERE are some points connected both with the appreciation and production of odors of animals which seem to require further consideration. It is generally agreed that all species, possessing the sense of smell at all, like and are attracted by the odor of their usual food, or of substances of an analogous nature. We have also evidence that animals are agreeably impressed by the specific odor of their own species, or, in the case of widely modified forms, of their own race or strain, and especially of individuals of the opposite sex. On the other hand, they are disgusted and repelled by the emanations of hostile species. These are the results which we might expect on evolutionist principles, and which we actually observe, whether we ascribe them to Prof. Jäger's soul particles or not. At the same time, we observe a few facts which we cannot well account for on the above mentioned principles. I take as an instance the feline family. The natural food of all such creatures is, indeed, the flesh and blood of recently killed animals; but, in case of need, they devour not merely carrion, but even excrementitious matter, and sometimes dig up the remains of the dead in cemeteries. We should naturally think that creatures capable of consuming such food must have preferences for odors not merely unlike, but totally opposite to those which we approve; yet the fact remains that not merely the domestic cat, but the African leopard, and indeed all Felidæ whose manners have been closely observed, are passionately fond of many odors which man selects and enjoys. Lavender, thyme, marjoram, pennyroyal—in short almost all plants rich in essential oils—have a well-known fascination for the cat. The leopard and the panther (if the latter is to be regarded as a distinct species) have been charmed into docility and submission by means of lavender water. It is difficult to understand on what principle purely carnivorous species can be attracted by scents so totally unlike that of their food; I may add, so totally unlike that of the animals themselves. A feline animal must, as a matter of course, find nothing offensive in the smell of its own species, and it is hard to conceive how, *e. g.*, a leopard can tolerate the smell of its own species, and at the same time can have a craving for lavender water. The difficulty becomes the greater if we consider that—at least as far as is known—nothing similar has been observed among the other groups of carnivorous animals, though one of them at least (the Canidæ) has a far more acute sense of smell than the Felidæ. With some hesitation I venture to suggest that the plants in question may act upon cats as an aphrodisiac. When these animals find, *e. g.*, a bed of thyme, chamomile, etc., they roll upon it, and indulge in demonstrations exactly like those which they manifest when under the evident influence of sexual excitement.

Prof. Jäger is of opinion that animals, man inclusive, are moved to fear or anger, as the case may be, by the odor of a hostile species. He maintains, with much probability, that the specific effluvium of a cat is offensive to mice, and causes them to avoid her presence and neighborhood; that of the tiger, he considers, is in like manner exceptionally offensive to mankind. Now the odor of the tiger, the lion, and other of the larger carnivora, is without doubt highly unpleasant; but I think a visit to the Zoological Gardens will convince any one that many smaller animals, not personally dangerous to man, give off a still more disgusting and noisome effluvium.

In many cases, an unknown or unaccustomed odor has a no less repellent effect upon animals than has that of a recognized enemy. Few beasts are at once more efficiently armed and more obstinately courageous than the grizzly bear, yet if he happens to approach a man from the leeward side, and detects his specific odor, without recognizing its source, he withdraws in another direction. Many other and much less formidable animals can only be approached from the lee side. Even in regions so solitary that the wild animals can have no acquaintance with man's peculiar effluvium, further than as a something unusual and inexplicable, they still take the alarm. Hence the hunter generally finds it necessary to proceed against the wind when in quest of his game.

This simple principle, the uneasiness caused by an unfamiliar odor, may serve to explain some facts which are very commonly put forward as manifestations of a mysterious "instinct." Thus, in laying traps, poison, etc., for wild beasts and vermin, from the tiger and the wolverine down to the rat, the objects in question retain a smell of the human person. The intended victim, on approaching, recognizes at once that he is in the presence of a something unknown, and he avoids the bait accordingly, or tries how he may obtain it without putting himself in peril.

Another very similar case is found in the felicity, if I may use the expression, shown by herbivorous animals in avoiding poisonous plants. Take an ox, a sheep, or a goat to a country where the flora is strange; he will browse upon plants analogous in odor with those which have formed his diet in his native country. But whenever he perceives a strange effluvium given off, he avoids the plant as doubtful. The same mistrust of an unusual odor has been magnified in the following case into a mysterious instinct:

The authorities of the Jardin des Plantes, finding themselves overstocked with bears, resolved to get rid of one by poison, and for this purpose gave the destined victim a bun upon which some prussic acid had been poured. The bear, noticing the unusual smell, immediately pushed the bun into the water, and let it wash till the obnoxious odor had disappeared. There is not the least reason to suppose that Bruin had an instinctive knowledge of the effects of prussic acid if swallowed.

All this will seem to us much more likely, if we reflect that nearly all mammalian species far surpass us in the sensitiveness of their scent organs. Besides this, they do not blunt these organs by the use of irritating condiments and so called "strong" drinks. What a difference may thus be produced, in the sensitiveness both of smell and taste, I had once an opportunity of noticing in the case of a lady, who, having been for some years a sufferer from neuralgia, was advised to renounce all hot liquids and all pungent condiments, such as mustard, pepper, etc. After long perseverance in this regimen, she acquired a delicacy both of smell and taste which was astonishing to her friends. Her verdict as to the wholesomeness and purity of a water supply was often of more than analytical accuracy.

But the lower mammalian animals have, as compared with man, a further advantage in the use of the sense of smell. Most of them can with ease bring the nose in contact with the ground, or with other low objects, which we can smell at only by dint of the tedious process of stooping, or by lifting the object up to our face. Hence in virtue of the triple advantage above mentioned, they can at once decide if an enemy or a desired prey has recently crossed their path, and left its specific emanations on the ground or in the air. They live, in fact, in a world of odors, just as we live in a world of sights; and just as our eyes are always conveying to us information, so are they constantly receiving impressions through their noses. An unwonted smell, too slight even to attract our notice, is to them as significant as an inexplicable noise or a strange sight is to us. What wonder, therefore, if they are disturbed thereby, and at once put upon their guard?

A few remarks may be needful on the odors given off by animals. In some cases—as that of the skunk and the common water snake—they are offensive and defensive weapons, consciously used under circumstances of danger. There are other cases where the specific odor may aid gregarious animals in finding their way back to their companions, or in recognizing their mates of the other sex. But it is at least questionable whether, in some instances, the odor of an animal, while not powerful enough to repel enemies, may not serve to inform them of its presence, and put them upon its track. I have never been able to see what benefit the fox derives from his very strong odor. Let us suppose that a strain of foxes were to be developed in this country whose scent should be only one-fourth part as intense as that of the ordinary Reinecke; would not such a strain, in virtue of the greater difficulty of following its scent, elude the hounds in a far greater number of cases, and in consequence be likely to gain ground upon and ultimately to supplant the ordinary loud-smelling breed? It may, of course, be argued that the scent of the fox does not expose him to any danger save the artificial one of a pack of hounds, and that fox hunting has not been in existence long enough for a less odorous strain to be evolved.

The perfumes of plants, and especially of their flowers and fruits, were till lately left out of consideration as quite unaccountable, or were—what amounts to the same thing—attributed to a perfectly arbitrary act of Divine will. Now a great approximation has been made to the truth of viewing both the odors and the colors of flowers as means for attracting such butterflies, moths, and birds as may aid in the process of fertilization. It is further held, on the principle of natural economy, that color and odor are mutually substitutes for each other. In fact, this is what is observed in a multitude, perhaps in the majority of cases. Many of the most brilliantly colored and conspicuous flowers are scentless, while on the same principle many of the most richly perfumed blossoms are white or pale yellow.

But to this rule there are a number of exceptions which require serious consideration. Not a few flowers of a decided coloration are well known for their sweet smell. As familiar instances, I may take the hyacinths, the sweet peas, the stocks, and wall flowers, the pinks and carnations, the red rose, the oleander, the auricula, the cyclamen, and the violet. The last mentioned flower is, however, very inconspicuous, and it is highly probable that it is indebted to its scent alone for the visits of bees. The original types of the auricula and of the wall flower were presumably the light yellow varieties we so often meet with. But though there are white oleanders, their original color is in all probability red, and the same may be said of the pink and carnation.

We have also to deal with the fact that so many white flowers are totally scentless—for instance, the large wild convolvulus and the pear-and-plum blossom. This peculiarity may seem less perplexing if we consider that perfume must be more especially serviceable for attracting night-flying insect visitors, such as moths. Now, the white convolvulus, like all its tribe, is a day opening flower and is always found tightly folded up at night. The white, scentless fruit blossoms open at a season of the year when few night-flying insects have made their appearance; consequently, their fertilization must depend on the visits of bees and butterflies. The questions then arise—are any flowers which close at nightfall odoriferous? and, on the other hand, are any species which bloom only in the night scentless? These points can only be studied to advantage in tropical countries, where many flowers open and close at fixed hours of the day, as was shown in the "floral dial" drawn up by Linnæus.

Another interesting circumstance is the number of flowers which emit odors more or less offensive to our sense of smell.

Among these rank many well-known garden favorites—dahlias, peonies, the tropæolums (commonly called nasturtiums, tulips, most of the lilies, the geraniums, the French marigold, the sunflower, *Coreopsis Drummondi*, the spotted meadow-orchis, the elder blossom, and many others. What is the especial function of these evil odors, and what enemies or unwelcome visitants do they repel? It must be noted, in the first place, that in perfume plants the stem and leaves are, as a rule, scentless, while the fragrance resides in the flower alone. Among the stench worts, "if they will allow me so to call them," the whole plant is impregnated with the evil odor, which is sometimes less powerful and striking in the flower than in the leaves and stem. We are apt to conclude that because bees, butterflies, etc., are evidently attracted to some flowers which are pleasant to us, therefore they must necessarily dislike and avoid what to us is loathsome and repulsive. This is a most unsafe conclusion. The beautiful green rose beetle is no less fond of the sickly smelling elder blossom than of the queen flower whose name it bears. The most beautiful butterflies—"æsthetic aristocrats," as Mr. Grant Allen calls them—will turn from banqueting on the nectar of flowers to sip the drainage of a dunghill or the juices of a putrid weasel or polecat, which to them may represent sauerkraut and venison. We do not, in fact, see that the ill-smelling flowers are in any signal way avoided by insects, whether enemies, such as the earwig, or those species which may aid in fecundation.

It may perhaps, be safely said that the majority of unpleasantly scented plants have flowers of a deep yellow, orange, brownish red, or brown color, and that blue, pink, rose, lilac, and violet colors are very rare among them, save in case of artificially produced varieties. A disproportionate number of such plants, further, belong to the family Compositæ, which, extensive as it is, scarcely includes a truly fragrant species. It can scarcely be denied that both pleasant and repulsive odors are respectively connected with certain families of the vegetable kingdom, and that the latter are preferentially correlated to certain colors and flavors. —*Journal of Science.*

HOW TO TRY A TELESCOPE, AND HOW TO USE IT.

By L. NIESTEN.*

ALL our schools will ere long be provided with telescopes, which, though of small dimensions, will enable teachers to familiarize themselves with the study of practical astronomy and permit them to show their pupils the principal curiosities that the heavens exhibit to us every night. We believe it will prove useful, then, to give in this place a little information as to the method of testing a telescope and of judging of its optical qualities, and to point out how it should be used and the precautions that should be taken to secure proper conditions for observations. Those of our readers who are desirous of acquiring an instrument capable of initiating them into the wonders of the heavens will also be benefited thereby, and the advice that we shall give them will enable them to make a judicious selection from among the telescopes which, in our day, different opticians are exposing for sale at relatively moderate prices.

An astronomical telescope consists essentially of two lenticular glasses placed at the extremities of a tube which serves to hold them at a proper distance from each other. One of these glasses is very wide, and is turned toward the object. This is called the *objective;* it reproduces the image of the object behind it at a point called the *focus.* The other glass, the *ocular,* has a much curved surface, and consequently a short focus, and magnifies the image given by the objective.

The aperture of the objective alone decides the quantity of light that will be admitted into the telescope and the clearness with which objects will be seen therein. This is the principal advantage of a large telescope over a small one.

As the glass of the objective is capable of admitting a greater quantity of light, the latter may be dispersed, without too greatly reducing it, by means of an eyepiece that magnifies highly. It would prove very advantageous, then, to increase the aperture to give more light to the objects; but the spherical form of our glasses does not unite the rays exactly at a single point, since the aberration due to sphericity is so much the greater in proportion as the aperture is wider. Objects become confused and badly defined when the aperture is increased sufficiently to render such aberration perceptible.

In the selection of an objective too much attention should not be paid to small bubbles and to the flaws that are found in the glass as a result of casting. What is especially important is that the surfaces of the lens be well finished.

To test an objective, care must be taken to choose a fine evening in which the air is calm; and the telescope, provided with its highest magnifying power, must be directed toward a star of medium magnitude. If the object glass is a good one the image will come rapidly into the focus, that is to say, outside of such point it will lose its sharpness on moving the eyepiece tube slightly backward and forward. The image of the star should exhibit, in a dark field, a small disk—a point almost perfectly round, without rays, aureoles or false image. Put out of focus, the image will give a series of very concentric luminous rings whose center will always be indicated by a brilliant point.

The images of objects of certain dimensions, such as the moon and planets, will be liable to be bordered or fringed with colors unless the achromatism of the objective be perfect. But, as it is very difficult in the manufacture of objectives to totally avoid the defect in achromatism, those lenses should be selected by preference that give, under such circumstances, images bordered with blue, while those should be rejected that give borders of yellow or red. Care should be taken, however, in these trials to employ different eyepieces, since the defect in achromatism may be due to the lenses composing these latter.

After this, it should be ascertained how the objective defines objects that are very close to each other, by examining in what manner the separation of double stars is effected. Knowing that the smaller the distance that separates the two components of a double star the greater will have to be the diameter of an objective in order to resolve them, we shall be able to effect the separation of certain of such stars by means of a given objective. Thus, it may be said that with an objective of 50 millimeters and a magnification of from 60 to 100, the companion of the Polar Star may be seen, and the following be easily separated:

α of Pisces, μ of Draco,
γ of Leo, η of Cassiopeia.

With a telescope of 100 millimeters aperture and magnifications of from 80 to 120 and beyond, the following ought to be separated:

β of Orion, σ of Cassiopeia,
α of Lyra, γ of Cetus,
δ of Gemini, ε of Draco,
ξ of Canis Major, ι of Leo.

Sometimes the definition of an objective may be remedied by diaphragming it, that is to say, by reducing its aperture. This is done by placing over the objective a card-board cap whose bottom contains a circular aperture that may be successively diminished by introducing against the bottom pieces of cardboard containing apertures smaller and smaller until a very sharp image is obtained. The defects in an objective may sometimes be corrected also by covering its central part with a paper disk. By thus limiting the aperture of the telescope we shall succeed in increasing the sharpness of the image, but as we have remarked above, we shall also diminish its light; so for objects that are not very luminous, such as comets and nebulæ, the entire objective should always be employed.

The eyepieces that can be used with a given objective are limited. In general it may be said that the strongest magnification that a telescope can bear is equal to the diameter of the objective expressed in millimeters, multiplied by 2. Thus, with a telescope of 75 mm. there may be used magnifications that may reach 150.

The astronomical telescope should be provided with at least three eyepieces, one of which will be of low power and wide field for stellar groups, nebulæ, and comets, and serve also to bring an object into the center of the field when it is desired to use a higher power. The medium eyepiece will serve to examine the sun, moon, and planets, and the highest power will be reserved for the stars. It is quite difficult to use the one last mentioned, inasmuch as the focusing of it being delicate, and its field being limited, much attention is requisite to keep the object in the telescope.

If the magnifying power of the eyepiece is not known, it may be determined approximately by looking directly with one eye at a divided scale (a brick wall will do for low powers), while it is fixed directly with the other eye, by counting the number of divisions of the scale, seen by the naked eye, that are comprised in one division of the magnified image.

The *field* of the telescope is the extent of the heavens that is seen in the instrument. The field is so much the smaller in proportion as the eyepiece is more powerful. It is very advantageous to know the diameter of the field that corresponds to each of the eyepieces with which the telescope is provided, and this may be ascertained by counting the number of seconds that a celestial object near the equator (γ of Virgo, or δ of Orion, for example) takes to cross the diameter of the field. Such an observation having been repeated several times, the mean of the time obtained is multiplied by 15, and this gives the diameter of the field in seconds of an arc.

The objective and eyepieces having been selected, the mounting of the telescope should next be examined to see that it presents those features of stability and rigidity that are requisite to secure for the image the immobility which is absolutely necessary for a good observation.

The tube of the telescope is usually of copper, and its inner surface is blackened so as to avoid reflections of light. To secure and exact focusing, it is well to effect the operation by means of a rack and screw, which will move the eyepiece smoothly to the proper distance.

Afterward, the telescope must be mounted upon a solid stand whose stability should prevent any oscillation in the instrument; for oscillation transmitted to the telescope would become amplified by the magnification employed, and make the images *dance* in the field. The telescope should be capable of being moved by the hand, and be so balanced that when directed toward an object it shall keep its position without being held by the observer.

It will prove advantageous in following celestial objects, to adopt an equatorial mounting to the telescope. This consists essentially of what is called a *horary axis,* which is inclined toward the horizon of the place, and which may be given a rotary motion, and of a second axis (*axis of declination*) fixed perpendicular to the first and carrying the telescope at one of its extremities. The telescope should, besides, be capable of revolving about this axis.

This arrangement, which we cannot too highly recommend, will permit the telescope, for a simple rotary motion of the horary axis, to follow any celestial body whatever during its diurnal course. But it will be necessary, before everything else, to take care that the horary axis is well located in the meridian, and that it is inclined to the horizon by an angle equal to the latitude of the place where the observation is made.

Let us now see what precautions should be taken in order to profit by all the advantages that a telescope can yield, and which, if neglected, may cause the observer to attribute to the objective an imperfection that it does not possess.

1. The observation should be made, if possible, in the open air. If it takes place in a room, care should be taken to open the window beforehand so as to bring about an equilibrium between the internal and external temperature, and, consequently, so that there shall be no currents of air to affect, through their agitation, the immobility, and hence the sharpness of the images.

2. The objective should be cleaned only in case of absolute necessity; and then, after care has been taken to remove the dust from it with a badger's-hair pencil, it should be rubbed gently with a chamois skin or with a soft and clean piece of linen.

3. The removal of the objective from the telescope should be avoided, because its adjustment is a delicate operation.

4. No time should be spared in bringing the image to a proper focus.

5. When an observation of the sun is made, care should be taken to place a piece of blackened or colored glass before the objective, so as to avoid grave accidents to the eyes.

6. Too high powers should not be employed, because there exists between the brilliancy and size of the image a proportion that cannot be modified. Beyond certain magnifications the image becomes weak and is effaced. The proper magnifications vary with the brilliancy of the object and the tranquillity of the atmosphere. For comets and nebulæ and for objects that are not very luminous the lowest powers must be used; but for the moon and the planets the magnification must be sufficiently great to diminish their brilliancy, and sufficiently small to preserve their clearness and definition properly. High power should be used only for the stars for separating them, etc.

7. The eye must be prepared for observations. Thus, in order to see very weak objects, the observer should remain in darkness for several minutes so as to allow the retina to preserve all its sensitiveness at the moment of the observation. Before observing double stars that are very close together, the eye should become accustomed to discern like objects, and the observer should therefore begin by looking at double stars that are somewhat distant from one another. In order to observe very feeble objects, such as the satellites of Saturn, it is sometimes advantageous to direct the sight to some distance from that point in the field in which the satellite ought to be found, or, to put it in the ingenious words of Arago, to perceive an object that is not very luminous it is not necessary to look at it. On a misty evening, brilliant objects are better defined. Twilight and moonlight are often advantageous as irradiation is thus lessened.

8. Observations near the horizon should be avoided as much as possible.

9. Finally, in making observations, the memory should not be relied on, and no neglect should occur to take notes of all that is seen.

*In *Ciel et Terre.*

A CATALOGUE containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

THE
Scientific American Supplement.
PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50, stitched in paper, or $3.50, bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
261 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ENGINEERING AND MECHANICS.—A New French Fire Engine.—4 figures.—General view.—Longitudinal section.—Rear view and half plan view of improved French steam fire engine..... 5799
Progress of Mechanical Engineering. By ROBERT H. THURSTON.—Materials.—Ingot iron.—Compressed steel.—Methods of manufacturing machinery.—Design.—Hydraulics.—Milling.—Transportation.—Electricity.—Steam.—Marine engineering.—Aeronautics.—Capital and labor.—Systematic promotion of industries.—Conclusions..... 5800
Mousseron's Smoke Consuming, Pipeless Stove.—3 figures..... 5804
How to Arrange Siphons.—4 figures.—Effective siphons, level and inclined.—Defective form of siphon.—Principle of the siphon..... 5804
Iron Direct from the Ore.—Broomfield's process.—4 figures..... 5805

II. ELECTRICITY, LIGHT, HEAT, ETC.—Electric Lighting. Its Costs and Appliances. By DR. CHARLES WILLIAM SIEMENS.—Efficiency and durability of dynamo machines.—Progress of electric lighting.—Best area of electrical districts.—Cost and dimensions of conductors.—Plant required to light London by electricity.—Comparative cost of illumination by electricity and by gas.—Gas as fuel..... 5806
Dangers of Electric Lighting..... 5808
Noel's Printing Telegraph.—3 figures..... 5808

III. GEOGRAPHY, ETC.—Underground Temperatures.—Summary of results obtained by the British Association Committee.—Instruments.—Methods of observation.—Questions affecting correctness of observations.—Questions affecting deductions from observations.—Comparison of results.—Mean rate of increase of temperature with depth.—Places of observation, etc..... 5811

IV. ART, ARCHITECTURE, ETC.—Design for a Preparatory School for Boys.—1 figure.—Royal Masonic Institution for boys, Wood Green, London..... 5806
Stove Chimney in Enameled Earthenware.—1 figure..... 5807
Brass Candlestick and Inkstand..... 5807

V. ASTRONOMY, ETC.—How to Try a Telescope and How to Use It. By L. NIESTEN.—Elements of a telescope and their functions.—How to select, care for, and use a telescope..... 5814

VI. NATURAL HISTORY, ETC.—A Photograph of Crocodiles.—1 figure.—Crocodiles photographed at Muygapier, near Kurrachee, Bombay..... 5813
Jottings on Odors and their Recognition. By J. W. SLATER..... 5813

VII. TECHNOLOGY AND CHEMISTRY.—Oxygen from the Air..... 5809
Water Gas as Fuel..... 5809

VIII. MEDICINE, HYGIENE, ETC.—A Living Double Monster.—Extraordinary example of teratology..... 5810

IX. MISCELLANEOUS.—Reading and Speaking.—By Prof. A. J. D. D'ORSEY, King's College..... 5805
Dr. Crevaux, the South American Explorer.—Portrait..... 5809

PATENTS.

In connection with the **Scientific American,** Messrs. MUNN & Co are Solicitors of American and Foreign Patents, have had 35 years experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all Inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured, with hints to procuring advances on inventions. Address

MUNN & CO., 261 Broadway, New York.
Branch Office, cor. F and 7th Sts., Washington, D. C.